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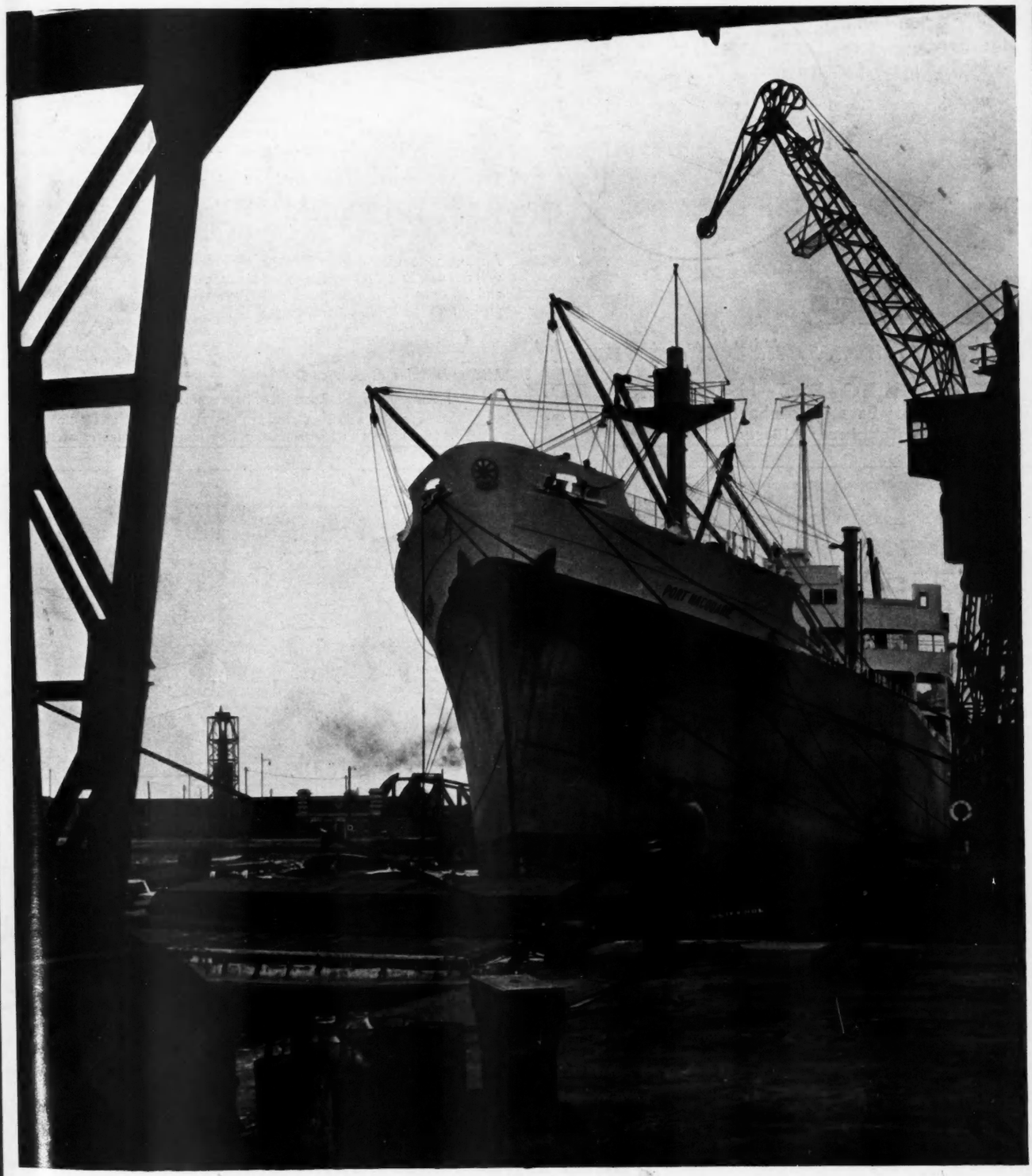

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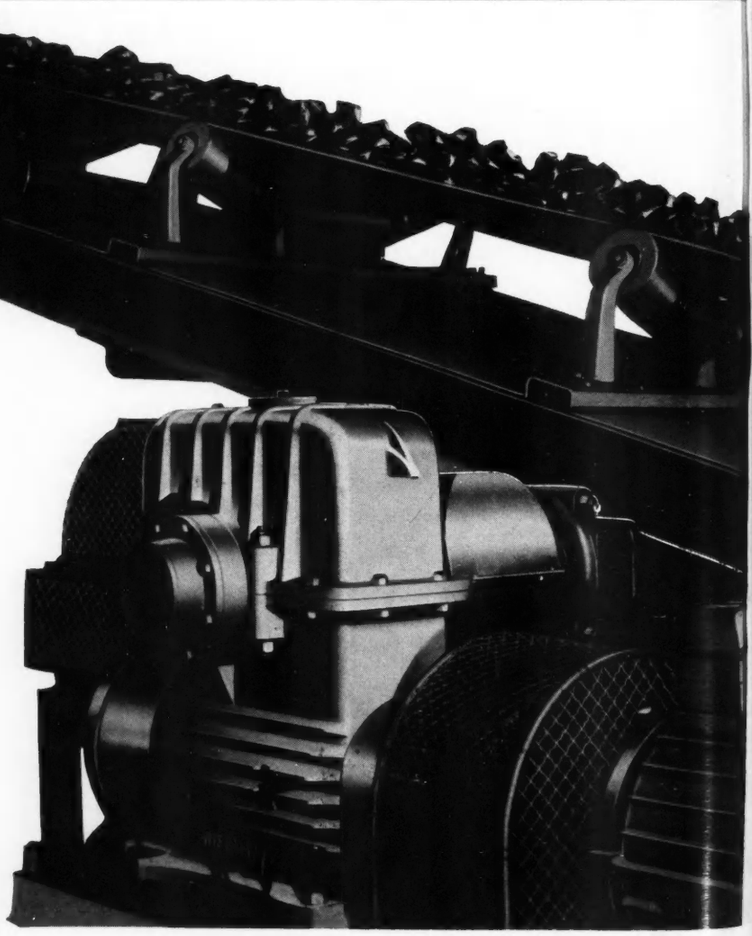

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Vol. 178 No. 4640 DECEMBER 31, 1954

Leading Article
The Case of Mr. E. 841

Weekly Survey
Sports Cars 842
Capital in the Electric-Motor Industry 842
Electric-Motor Maker 842
"Non-Reflecting" Glass—and Machine Tools for Hire 842
Latin America 842
Selling Cycles 843
Timber in Europe 843
Reorganisation at Vickers-Armstrongs 843
Paper-Making Machines 843
Plastics for Making Dies 843

Principal Articles
The Wilkinson Monument at Lindale 844
Centenary of the Crimean War: Birth of Armoured Iron Ships 846
Increased Production of Epikote Resins: Uses in Surface Coatings and Plastics 848
Hydro-Electricity in Ontario 848
Powder Metallurgy: A Survey of Recent Advances 850
The Michell Bearing: Practical Experience and a Theoretical Investigation 854
Autumn Meeting of the Iron and Steel Institute: Fatigue Tests on Rolled Alloy Steels 854
Attenuation of Vibrations by Leaf Springs: Reducing Inter-Leaf Friction 856
Short-Circuit Forces on Alternator End-Windings 856
High-Pressure Boilers: Past and Present Developments and Future Trends 857
The Andritz Oil Engines: Efficient Two-Stroke Designs for Stationary or Marine Duty 858
Viscount for Canada: Powered by Dart 506 Engines 864
Eland Gas Turbines for Rotodyne Helicopter 864
Inspecting Gas-Turbine Components 865
Extended-Surface Heat Exchangers: Unit Construction 866
Grinding and Lapping: Two-Speed Independent-Spindle Machine 867
Drying Varnish Rapidly 867
Hand Grinding with Tool Face Always Visible 868
Automatic Feed on Bench Power Presses 868
Plastics Pipelines for Cold Plumbing 868
Coal Cutting and Loading in One Operation 869

Obituary
Sir Ernest Lemon, O.B.E. 845
Dr. G. F. C. Searle, F.R.S. 845
Mr. Arthur Scrivener, M.C. 845

Book Reviews
Engineering for Agricultural Drainage 849
Jane's All the World's Aircraft, 1954-55 849

News
Electricity in November 844
Radio Valve Assembly by Induction Heating 864
Lubrication at a Distance 864
The Human Touch in Industry: Plans for 1956 Conference 865
School of Aeronautics at Belfast 867
Hydro-Electric Work in Scotland 868
Hydro-Electric Power for Uganda: Film 869

Personal 844, Business Changes 845, Contracts 848, Trade Publications 849, Books Received 850, Launches and Trial Trips 863, Forthcoming Exhibitions and Conferences 870, Notices of Meetings 871, Labour Notes 872

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THE CASE OF MR. E.

It is convenient to call him Mr. E. because he is now an engineer; but it was not always so. Before he finally chose to be an engineer—he is still only 31—he had studied for two different professions and had served in the Forces during the war.

When he was a boy his father wanted him to be an engineer, but he studied classics at school and sat for a classical scholarship to Cambridge. He failed—partly due to his youth—and in the same term his father died and the war broke out. There was no tangible reason why he should not have gone to Cambridge, but life for him had suddenly become disorganised. At the end of the year he left school. For purely personal reasons he took a job in London, as a clerk at the Law Courts, intending to study law in his spare time. But the personal reasons faded away and the job remained; a job that bored him unutterably. After three months he decided he would become a doctor. He studied for a year for his first Bachelor of Medicine examination.

During this year the war had ceased to be "phoney." School friends and acquaintances were now in the Services, some covering themselves with glory. He told himself that if he failed his examination at the end of the year he would join up. He failed, and joined the Army.

As a troop leader in charge of 20 men he found a new feeling of responsibility. He liked the team work, and the practical problems that had to be solved—a bogged tank which had to be recovered in the dark without showing lights; the movement of a column of tanks along crowded and crumbling roads; the feeding and welfare of his 20 men. When he was demobilised at the age of 23, the five years of Army experience helped him to decide on a career. After two false starts he now knew he wanted to do what his father had always wanted for him. It was the contact with other men—the human as well as the technical problems—which drew him to engineering. And in a world devastated by six years of war, engineers would be much needed. They should be able to command a good price for their services.

Training at college was hard after five years of mental inactivity, but it was absorbing. It was refreshing to be back in an academic atmosphere. The new subjects of engineering were a challenge. After a while the question had to be answered, what kind of engineer? Civil, mechanical, electrical, chemical, or what? For a reason which may have been wrong, and was certainly trivial—namely, an abhorrence of the drawing board—he decided that electrical engineering was the only course which would not tie him to the drawing board.

After three years he passed all his examinations, and then had to look for a job. A graduate apprenticeship was needed first, because of his lack of practical experience and because it would give him more time to observe the electrical engineering world in general. To be sure of acquiring a broad outlook he did his apprenticeship with an electricity board, and thus saw electricity being generated, distributed and used in many different places. He worked, also, at the bench in a factory.

When these two years were completed he joined the electrical department of a large manufacturing firm, where electricity was a servant—an indispensable servant—to production. The job offered plenty of constructive work, and contacts with a variety of people, many of them not connected with engineering.

So far, his career has been satisfying if rather tortuous. He feels he has gone some of the way along the road he wants to go, and now he wonders which direction the road ahead will take. He has a desire, like many others, for independence. The nature of engineering is such that it is impossible for there to be many masters; most engineers have to be the servants of others. He sees two courses open to him. He can try to start a small business of his own, borrowing money if he has to and can, and working to full stretch for himself and his family. This would undoubtedly be the course he would enjoy most. Alternatively, he can work in partnership with others, each having his own responsibilities and decisions, and each with greater financial backing than he would have on his own.

That is Mr. E.'s story to date. In seeing that possibility of a choice in planning his future—a possibility which many of his contemporaries would never envisage—he is clearly under the impression that an employee, however senior, is a tool in the hands of his employers. Many employees are—because that is their nature—but for those, like him, who are prepared to start on their own, there is ample scope in established firms. Change is the order of the day in engineering, and engineers are needed who will assume responsibility for change; who will seize responsibility and not wait for it to be thrust upon them.

An unusual tale, Mr. E.'s; not many engineers go through such a period of trial and error. But in a brief biography like this there are the elements of many of the topics that interest conferences of educationalists and industrialists to-day. There should be more case histories, fewer abstract arguments, for the conferences to examine.

Weekly Survey

SPORTS CARS

The performance of British sports cars in competition throughout the world during the past few years has given the industry a remarkable lead which they are striving hard to maintain. Jaguar Cars, Limited, were pioneers in this field in so far as they were the first makers of a fast high-powered sports car to establish themselves on a substantial scale in the North American market. Others have entered the field since, and with varied success, notably Aston Martin, Austin-Healey, Bristol, M.G., Triumph, and Allard. (Allard, were, in fact, among the first, though not on such a large scale as Jaguar.) Now Continental car makers are becoming more competitive. At the Motor Show the new Mercedes Benz 300 SL, fitted with a three-litre petrol-injection engine, attracted much attention. A top speed of 165 m.p.h. was quoted, though it appears now that the makers do not guarantee this figure to an ordinary customer who wishes to purchase one to-day. The recent Jaguar decision to offer for ordinary sale their "D" type car as a standard production competition model is, outwardly, a British answer to this German challenge. Jaguar Cars North American Corporation, the United States subsidiary, have stated that it is the only stock competition-model sports car capable of road speeds in excess of 172 m.p.h. The Jaguar car is, of course, essentially a track car, whereas the Mercedes is a road car.

Few people would seriously regard these very high road speeds as either desirable or necessary. British roads are certainly not the place for them. But the glamour of owning the fastest car on the road is a powerful attraction, and even if an owner never uses the highest speed attainable he can derive pleasure in handling a car which, because of its racing background, handles superbly well. High speed by itself is not particularly difficult to provide in a car; it is the road-holding, braking and high-speed cornering qualities of British sports cars which distinguish them from the American designers' conception of a sports car, and racing develops these qualities.

Racing is undoubtedly of great technical assistance to the sports car maker. From the publicity point of view it must be successful racing otherwise it does more harm than good. This was affirmed by Mr. David Brown, whose companies build Aston Martin and Lagonda cars, in an article which appeared in a supplement to the *Financial Times* last October. The continuance of British exports to North America depends on a number of intangible factors, in addition to the obvious points such as price and technical quality. The little M.G., for example, has been extraordinarily successful in the United States, chiefly because of its "novelty value." Price, high speed, handling qualities, technical design lead—separately or together they may not be enough.

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CAPITAL IN THE ELECTRIC-MOTOR INDUSTRY

How far is the higher productivity of American companies due to the greater amount of capital used there? This question has frequently been posed following the visits of productivity teams to the U.S.A. Apart from the reports of these teams, detailed information on productivity in individual U.S. firms is available in the "Case Study Data on Factory Performance and Productivity," compiled by the Bureau of Labour Statistics in Washington and available in this country from the British Institute of Management, but hitherto it has not been easy for British managements to compare their capital requirements with those of similar U.S. firms and to study the effects on profit and liquidity of the use made of financial resources in individual American firms.

A simplified method of comparison is given in a report on U.S. capital requirements and operating ratios dealing with the electric-motor industry issued by the U.S. Foreign Operations Administration and obtainable from the British Institute of Management (price 5*s*.). The report does not make direct comparisons between the U.S. industry and its counterpart in other countries but provides a series of percentages and ratios applying to American electric-motor manufacturers, with which comparisons can readily be made. The use of ratios and percentages obviates the need for converting American financial data into different national currencies. It may come as a surprise that in 1951, in the case of U.S. electric-motor manufacturers employing 500 and over, income taxes took 66 per cent. of total profits and dividends 13 per cent., while 21 per cent. was retained in the business.

It is suggested that by calculating similar ratios and percentages for their own companies, manufacturers in other countries can obtain valuable information as to whether capital is being effectively used or whether, for example, the company might be undercapitalised for manufacturing and over-capitalised for trading and whether an adequate proportion of profits are being re-invested. The report makes a number of suggestions regarding the comparisons which should be made and the conclusions to be drawn from them. In all such comparisons between industries in different countries difficulties must arise as regards the strict comparability of the figures used and their interpretation under differing market and trading conditions. The report, however, sets out the methods used for the American companies in considerable detail and it should not prove difficult for manufacturers in this country to make reasonably valid comparisons.

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ELECTRIC-MOTOR MAKER

At the annual general meeting of Crompton Parkinson, Limited, the chairman, Mr. Albert Parkinson, M.B.E., was able to report a further successful year. The combined output of electric motors, generators and rotary convertors, which accounts for a high proportion of the company's output, has been remarkably steady over the last three years, the monthly average for the first six months of 1954 being £3·7 million compared with £3·6 million for each of the two preceding years.

These figures, however, mask a fall in the output of general industrial equipment in the range of 1 h.p. to 250 h.p. common to both home-market sales and exports, and rises in that of both fractional horse-power motors and heavy plant of over 250 h.p. It seems quite probable that these trends will continue in the current year, though looking further ahead it is possible that the downward trend in home sales of industrial motors may be reversed in view of the very sharp rise in plans approved for new factory construction in the first nine months of 1954. During this period the number of new factories approved rose to 1,958 compared with 1,398 in the corresponding period of 1953. If this rate is maintained for the final quarter of the year the total for 1954 will beat the record figures for 1949. The rise in the output of fractional horse-power motors from a monthly average of £674,000 in 1953 to £858,000 in 1954 is partly due to increasing export demand, but mainly to the expansion in home sales of vacuum cleaners, washing machines and other domestic electrical appliances which has taken place during the past year, and to which further impetus was given by the relaxation of hire-purchase restrictions in July (see Weekly Survey for November 26, 1954).

In exports Crompton Parkinson were able to record an expansion during the past year in spite of a growth in the range and capacity of their factories in three of the principal export markets, namely, Australia, India and South Africa. The potentialities of the "Iron Curtain" markets were not overlooked and the chairman claimed that a visit by the company's representatives to the U.S.S.R., which achieved considerable publicity, had played a significant part in the development of a more liberal policy towards East-West trade. He concluded that conditions were tending to improve in both home and export markets, though increasing competition is already resulting in a lowering of the average price obtainable and the cost of getting the orders.

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"NON-REFLECTING" GLASS—

A Weekly Survey note in our issue of November 19 referred to the development by Pilkington Brothers, Limited, of a glass which has reflective properties substantially below those of most types of glass. This characteristic makes it extremely valuable for many purposes where clear vision is required, particularly for the covers of gauges and other instruments. It obviates the difficulty which is often experienced in reading dials when they are wrongly positioned in relation to the lighting points or windows. Pilkington's, however, make no claim that the glass is completely non-reflecting and we therefore regret that the title we used for the note—Non-Reflecting Glass—has given a misleading impression.

—AND MACHINE TOOLS FOR HIRE

Another note—on the hiring and hire-purchase of machine tools (October 22)—has also caused some trouble. We are now informed that although only a few British machine-tool firms finance this type of operation, the scale on which certain individual firms conduct it is very considerable.

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LATIN AMERICA

British exports to Latin America can be increased from their current annual rate of about £130 millions to £400 millions a year during the next five years. This is the view of Mr. J. P. Ford, chairman of the Institute of Export and managing director of the export companies of the Brush Group Limited, on whose behalf he has made a three months' tour of thirteen Latin American countries. At a Press conference held last week, Mr. Ford said that he had found a vast and urgent need for a wide range of plant and machinery which can be supplied by British manufacturers at prices and on delivery terms fully competitive. Much of what he said was clearly based on his personal observations of the "feverish activity" that characterises industrial expansion on the Latin American Continent.

Mr. Ford said that the British sales resources were at present very thinly spread and urged British manufacturers of capital equipment to "send out senior directors who could see what was happening and groom their products to local demands." In his review of principal markets, Mr. Ford singled out Venezuela as offering the biggest market for immediate expansion of British exports, particularly for machinery and plant for oil production, iron-ore mining, building and civil engineering and agriculture. In Brazil, the picture was more encouraging now than before the change of Government, partly because of a sounder financial policy. The country's sterling debt had been reduced from £63 millions to £38 millions in a year, and although currency restrictions will doubtless remain for some time, the long-term prospects have improved. The shortage of sterling and the growth of local manufacture are the two principal obstacles to increased trade with Argentina. Mr. Ford was surprised to find the local engineering industry sufficiently developed to produce alternators of 1,500 kW. He pointed out that such developments make it essential for British exporters to set up manufacturing facilities locally, a policy which is being energetically pursued by United States, German and Italian companies.

Many of the suggestions made by Mr. Ford were those of a practical technical salesman—

that service facilities, for example, should be set up equal to the best offered by competitors, and that a bigger effort should be made to train in this country Latin American students and engineers. Underlying most of his statements, however, was the personal conviction that there was much business to be done despite currency and other difficulties. Mr. Ford pointed out that loans by the World Bank were not tied and that contracts were awarded to the lowest tender. As an example of the great opportunities for British exporters, Mr. Ford mentioned that one British manufacturer of aluminium houses, exhibiting at the Bogota trade fair, had booked £2 millions worth of orders.

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SELLING CYCLES

The British cycle industry is now well on the road to prosperity. Output for the first nine months of 1954 admittedly was only about 6 per cent. above the level of 1953 and the increase in exports even smaller, but the improvement has been very marked in recent months and the output of 322,000 machines in September is the highest monthly figure since the peak year 1951.

In an industry dependent upon exports for nearly 70 per cent. of its output, prosperity can never of course be assured—although the industry has shown remarkable ingenuity in the past few years in adapting its sales and production techniques to meet the requirements of new markets when faced with drastically reduced sales in some of their established markets. Thus, after 1951, when the fall in income in the primary producing countries greatly reduced exports to Malaya, the Belgian Congo and Latin America, the North American market was exploited to such good effect that the United States took over 400,000 British cycles in 1953, compared with about 120,000 in 1951. Exports to the United States fell back slightly in the first half of 1953, but in September were nearly twice as great as the monthly average for 1953. Unfortunately, future prospects are marred by the possibility that the United States Tariff Commission (after having once rejected one) may grant an application from United States manufacturers for an increase in tariffs.

Despite the hazards, British manufacturers are extremely optimistic about their prospects. The Birmingham Small Arms Company report that their business in pedal cycles is having striking success against competition overseas. Raleigh Industries, Limited, have started to erect a new factory and are planning another, and the Halford Cycle Company have just reported record profits—43 per cent. higher than the year to September, 1953.

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TIMBER IN EUROPE

The engineer's attitude to design problems and completion dates has been conditioned since the war to some extent by the shortage of timber. Supplies have become less scarce in the last year or two but there is no doubt that any inclination there may have been to experiment with alternative materials, such as plastics, has been strengthened by the high price of timber, notably softwoods. A report has now been published by O.E.E.C. on the timber industry in Europe which sets the current prospects of the European timber industry against its post-war background.

The main feature of the post-war market has been the decline in the exports from Eastern Europe, which was offset to a limited extent in the immediate post-war years by the intensive exploitation of forests in Western Germany. The general export shortage was eased to some extent by the enforcement of strict controls in the United Kingdom, which accounts for about 50 per cent. of the total imports of sawn softwood into O.E.E.C. countries. These controls were removed in November, 1953. This artificial equilibrium of demand and supply at a low level had a number of important consequences. Prices rose, and what was traditionally a plentiful and cheap raw material became expensive. Easy-going habits in wood consumption had to be unlearned. Efforts were made to find alternative supplies by developing local forest conservation (in this country the pre-war afforestation programme was intensified) and tropical timbers have been used and are likely to maintain some sort of a market in Western Europe. These last, however, are mainly hardwoods. Research work was done on the more economical use of timber and substitute materials were developed.

The report is cautious about the long-term prospects for the European timber industry and it does not expect the consumption of timber to increase as rapidly as general economic activity. It is inclined to the view that expansion depends very much on lower prices and these can be achieved only if the techniques of production are modernised. A good deal has already been learned on this subject by teams visiting the United States. Broadly, therefore, the report hints at a gradual increase in supplies and slowly falling prices.

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PAPER-MAKING MACHINES

There are indications that companies in that highly-specialised section of the British engineering industry—paper-making machines—have expanded their business considerably during the past few years. Production was increasing before the war and rose by 25 per cent. between 1935 and 1939; the war, however, had a most disruptive effect on the industry, and production in 1948, at 7,100 tons valued at £3 millions, was 25 per cent. below the pre-war volume. Since that date, however, the two largest manufacturers, Millspaugh, Limited, and Walmesley (Bury) Group, have reported substantial extensions to their factories. Mr. John Wolstenholme, chairman of Walmesley (Bury) Group, told the company's shareholders at their annual general meeting on December 10 that they were beginning to reap the benefit from their post-war programme of expansion, which had resulted in doubling, since 1946, the floor area occupied by the Group's factories. At the annual general meeting of Millspaugh, Limited, held last February, Mr. J. B. Thomas, the chairman, announced that several major extensions to their production facilities were nearing completion, including the Had-Mil Works at Sheffield. The firm celebrates its 21st anniversary this year.

The industry's sales are fairly evenly divided between home and export. Before the war exports accounted for just over 46 per cent. of output, and in 1948 for just under 40 per cent. The value of exports rose from £3·2 millions in 1952 to £4·1 millions in 1953, and during the first ten months of this year were being maintained at approximately the 1953 level, despite the recession in North America. The paper and pulp industry in the United Kingdom has reached a high level of prosperity during the past two years, and prospects appear to be good. Production of paper and board, excluding newsprint, rose from a weekly average of about 38,100 tons in 1953 to 46,100 tons during the first nine months of this year. Production of newsprint, which averaged 11,600 tons a week, increased slightly but remains over one-third below the pre-war level and is inadequate to meet home demands. There are thus no signs that the demand for pulp- and paper-making machinery has reached its peak, and orders on hand are said to be very satisfactory.

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REORGANISATION AT VICKERS-ARMSTRONGS

Vickers-Armstrongs Limited have announced as a preliminary step in the reorganisation of the company's structure, the formation of three subsidiary companies, Vickers-Armstrongs (Aircraft), Limited, Vickers-Armstrongs (Engineers), Limited, and Vickers-Armstrongs (Shipbuilders), Limited, as reported in Business Changes this week. No further information regarding the nature and scope of this reorganisation has yet been released, but it is fairly clear that the products within the control of each new company will be sufficiently generic to enable grouping of administrative machinery on a more functional basis and the setting up of central services of more direct value to the manufacturing companies than has been possible hitherto.

For example, it is assumed that the Naval Construction Works at Barrow and the Naval yard at Walker will be organised under Vickers-Armstrongs (Shipbuilders), Limited, and that the Supermarine Works, Swindon, and the Weybridge works will be organised under Vickers-Armstrongs (Aircraft), Limited. On the other hand there is a substantial general engineering output at Barrow, including cement plant, soap machinery, winding plant for mines, ink mills, etc. The grouping of products under Vickers-Armstrongs (Engineers), Limited, will therefore be far from straightforward as the company will be responsible for many different products. Armament factories such as the Whitehead Torpedo Works (now doing subcontract work for the aircraft companies), and the Thames Ammunition Works, have no obvious place in any of the three new companies.

Another problem, which would appear to remain untouched, is the existence within the Vickers Group but outside Vickers-Armstrongs of companies making products closely allied to those made by Vickers-Armstrongs companies. For example, Onions & Sons Levellers, Limited, make earth-moving machinery which is closely related to that made at Elswick and to that subcontracted by Jack Olding and Company, Limited, to companies outside the Vickers Group such as the North British Locomotive Company. Palmers Hebburn Company, Limited, the ship repairers, are another example of a company whose activities are closely related to Vickers-Armstrongs (Shipbuilders), Limited, but outside the Vickers-Armstrongs organisation. Central planning and co-ordination will doubtless remain the responsibility of Vickers, Limited, who, with over 80,000 workpeople, are the largest unit in British engineering. It will be interesting to see what steps are taken to rationalise further the organisation of the Group as a whole.

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PLASTICS FOR MAKING DIES

The word plastics is used so often to describe the material from which both household and engineering articles are made that many people would find it difficult to define. The definition in the British Standard "Glossary of Terms Used in the Plastics Industry" is: "A wide group of solid composite materials which are largely organic, usually based on synthetic resins or upon modified polymers of natural origin, and possessing appreciable mechanical strength." Development of the use of plastics can proceed along two main lines: new methods of using existing synthetic or natural resins; and the production of new synthetic resins.

The Shell Petroleum Company produced a new synthetic resin "Epon" in the United States five years ago, and production is now running at 11,000 tons per year. A plant to produce this resin has been operating in Holland for eighteen months, and in the middle of 1955 production will begin at Shell's new plant at Stanlow, Cheshire. The resin, called "Epikote" outside the United States and Canada, is used partly to produce coatings and finishes by combination with other materials, but also has many useful applications in engineering fields. It is made into dies suitable for the automobile and light metal industries: it can be used for laminating, where its adhesive properties are outstanding; to make heat stabilisers for vinyl compounds; and for the "potting" of electrical assemblies. A further article in this issue describes Epikote and its uses in greater detail.

THE WILKINSON MONUMENT AT LINDALE

John Wilkinson, the famous ironmaster whose boring mill contributed so much to the success of James Watt's steam engines, was born in Cumberland, in 1728. Part of his boyhood was spent at Backbarrow, in North Lancashire, where his father, Isaac Wilkinson, had acquired a charcoal-fired iron-smelting furnace, the remains of which were still in fairly good preservation when, in 1938, the Newcomen Society visited the site during their summer meeting. In 1748, Isaac left Backbarrow and established himself at Wilson House, near Lindale-in-Cartmel and, at about the same time, John Wilkinson made his way south to Staffordshire in search of wider experience. It was probably about seven years later that Isaac Wilkinson leased the iron furnace at Bersham, near Wrexham; but he did not hold it for long, his sons John and William taking over the works in 1762, and ultimately becoming sole proprietors.

The cast-iron monument to John Wilkinson, showing the inscription and the repairs that have been made.

About 1765, although his business activities were still in the Midlands, John Wilkinson purchased the estate of Castle Head, close to his old home in Lindale, which is not far from Grange-over-Sands; and in the garden of the new house that he built there he kept, in open view, a number of iron coffins, in one of which, according to his instructions, he was to be buried. When he did die, on July 14, 1808, it was found that none of the coffins was large enough to contain his remains and a bigger one was ordered from his works at Broseley; meanwhile, he was buried in the garden. When the new coffin arrived, he was reburied in the grounds of Castle Head and a cast-iron obelisk was erected over the grave. It bore on the shaft a portrait medallion and on the base the following inscription: "Here rests John Wilkinson, Ironmaster, who died XIV July, MDCCCVIII, aged LXXX Years. His Different Works in Various Parts of the Kingdom are Lasting Testimonies of His Unceasing Labours; His Life was Spent in Action for the Benefit of Man; and, as He Presumed Humbly to Hope, to the Glory of God." On the plinth was his own motto, "Labore et Honore."

In 1828, when the estate was about to be sold, the coffin was exhumed and reburied in Lindale churchyard, but with nothing to mark the spot. The monument, which had been dismantled to permit the coffin to be removed, lay in that state until 1863, when it was re-erected at a road junction in Lindale. The top line of the inscription, "Here rests," was chipped off, as it no longer applied, though traces of the letters can still be seen. In course of time, the monument began to show signs of deterioration—accelerated, no doubt, by the years of neglect when it lay in the garden of Castle Head—and eventually it became badly cracked. The medallion fell off, but fortunately was rescued and preserved until such time as the monument could be reconditioned.

In 1953, the attention of the Newcomen Society was drawn to the state of the memorial and to the evident fact that, unless its repair was soon undertaken, restoration might become impracticable. The Allithwaite Parish Council, in whose area it stands, could spare no funds for the purpose, nor were the Ministry of Works prepared to take it in charge. Eventually, however, the Institute of British Foundrymen and the Newcomen Society jointly assumed the responsibility and, partly by welding and partly by the use of fitted steel clamps, sufficiently repaired and reinforced the structure to prevent further deterioration; though, it must be admitted, at some loss of appearance. As a further protection, the obelisk has been painted. It weighs about 20 tons and was cast in John Wilkinson's ironworks at Bradley, in South Staffordshire. We are indebted for the accompanying illustrations of the restored monument to Dr. W. H. Chaloner, of the University of Manchester.

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ELECTRICITY SUPPLY IN NOVEMBER

During November, 1954, 6,351 million kWh were sold by the British Electricity Authority to the Area Boards. This was an increase of 14·5 per cent. over the figure for November, 1953. When corrected for the weather, which was colder than a year earlier, and for the number of effective working days, which were more, the increase was 11 per cent. The amount of electricity sent out by the Area Boards was 6,216 million kWh, while 135 million kWh were supplied direct by the Central Authority. The increases in the amounts sent out, compared with the corresponding figures in November, 1953, were 14·2 per cent. in the "mainly industrial" areas and 13·3 per cent. in the "mainly non-industrial" areas.

PERSONAL

SIR JAMES REID YOUNG, C.A., F.C.I.S., is relinquishing his executive duties and retiring from his seats on the boards of subsidiary companies of Vickers Ltd. as from to-day, December 31, 1954. He remains a director of Vickers Ltd., and Metropolitan-Cammell Carriage and Wagon Co. Ltd. THE VISCOUNT KNOLLYS, G.C.M.G., M.B.E., D.S.C., is appointed deputy chairman of Vickers Ltd., as from January 1, 1955. MAJOR-GENERAL C. A. L. DUNPHIE, C.B., C.B.E., D.S.O., is appointed chairman of Vickers-Armstrongs Ltd., with effect from January 1, 1955, and retains his present office of managing director. MR. E. J. WADDINGTON, A.C.A., who relinquished the office of secretary, joins the board of Vickers Ltd. on January 1, 1955, and is appointed director of administration of that company. His office of director of administration of Vickers-Armstrongs Ltd. is extended to that of director of finance and administration. MR. E. P. TOMLINSON, A.C.A., is to be secretary of Vickers Ltd., as from January 1, 1955. VICE-ADMIRAL SIR CHARLES SIMEON, K.B.E., C.B., is retiring from his directorship of Vickers-Armstrongs Ltd. to-day, December 31.

SIR HAROLD BOWDEN, Bt., G.B.E., is to retire as chairman of Raleigh Industries Ltd. as from January 1, 1955, and will be succeeded by MR. G. H. B. WILSON, the present deputy chairman and managing director.

SIR EWART SMITH, M.A., M.I.Mech.E., technical director, Imperial Chemical Industries Ltd., who has been deputy chairman, for the past year, of the British Productivity Council, 21 Tothill-street, London, S.W.1, has succeeded MR. TOM WILLIAMSON, C.B.E., J.P., as chairman of the Council on the latter's conclusion of his year of office on December 15.

SIR REGINALD HILL, K.B.E., C.B., M.Inst.T., chairman of the Docks and Inland Waterways Executive from its creation in 1947, and, later, chairman of the joint board of management, constituted temporarily when the Executive was abolished in 1953, is relinquishing his appointment. The temporary board has ceased to exist as a result of the appointment of general managers for the British Transport Commission's docks and inland-waterways activities, respectively.

SIR ALEXANDER AIKMAN has relinquished his position as chairman of Electric and Musical Industries Ltd., Hayes, Middlesex, but remains a member of the board. MR. J. F. LOCKWOOD has been elected chairman in succession to Sir Alexander.

THE RT. HON. THOMAS JOHNSTON, C.H., has been appointed to the Board of Governors of the British Broadcasting Corporation from January 1, 1955. He will be National Governor for Scotland and chairman of the Broadcasting Council for Scotland.

MR. J. C. GRIDLEY, C.B.E., chairman of the Vacuum Oil Co. Ltd., has been elected a director of Powell Duffryn Ltd., 19, Berkeley Street, London, W.1.

CAPTAIN (E) L. A. B. PEILE, D.S.O., M.V.O., has been promoted to the rank of Rear-Admiral (E) from February 21, 1955. He will relieve REAR-ADMIRAL (E) C. LITTLEWOOD, C.B., O.B.E., assistant director of dockyards, who is being placed on the Retired List.

MR. E. W. S. PRESS has been promoted to be deputy chief scientific officer, Ministry of Supply, and has been appointed director of chemical inspection, Kidbrooke.

The officers of the Royal Society, Burlington House, London, W.1, elected for the ensuing year are: as President, DR. E. D. ADRIAN, O.M.; as treasurer and vice-president, SIR THOMAS MERTON; as secretaries and vice-presidents, SIR EDWARD SALISBURY, C.B.E., and SIR DAVID BRUNT, and as foreign secretary, SIR CYRIL HINSHELWOOD.

MR. H. W. SIMPSON, M.A., LL.B., at present deputy secretary, North of Scotland Hydro-Electric Board, is succeeding, as secretary, MR. W. D. D. FENTON, the Board's present secretary and commercial engineer, who is leaving on January 20, 1955, to take up his new post of deputy chairman of the Uganda Electricity Board. MR. J. C. N. BAILLIE, at present development engineer of the North of Scotland Board, is to be chief commercial officer.

DR. C. J. SMITHELLS, M.C., director of research, the British Aluminium Co. Ltd., has been awarded the Institute of Metals (Platinum) Medal for 1955. The Rosenlain Medal for 1955 of the Institute of Metals has been awarded to DR. W. A. BAKER and the W. H. A. Robertson Medal and Premium for 1954 to PROFESSOR HUGH FORD and MR. J. G. WISTREICH.

MR. A. G. STEWART, chairman and general managing director, Stewarts and Lloyds Ltd., has been appointed President of the British Iron and Steel Federation, Steel House, Tothill Street, London,

S.W.1, as from January 1, 1955, in succession to MR. G. H. LATHAM, chairman and managing director, Whitehead Iron and Steel Co. Ltd. SIR ERNEST LEVER, chairman and chief executive officer, Richard Thomas & Baldwins Ltd., and the Steel Company of Wales Ltd., has been appointed President elect.

MR. L. HOWLES, C.B.E., M.I.E.E., M.I.Struct.E., F.R.S.A., chairman of the South-Western Electricity Board, has been elected chairman of an Industrial Development Committee appointed by the Council of the British Electrical Development Association with the object of fostering and developing the use of electricity in industry. MR. J. F. SMITH, B.Sc., M.I.E.E., chief commercial officer, South Wales Electricity Board, has been elected vice-chairman of the committee.

MR. K. S. PEACOCK, chairman and managing director of Guest, Keen and Nettlefolds Ltd., has been elected a director of the United Steel Companies Ltd.

MR. A. S. PEACOCK has been appointed manager of the expanding activities, in Latin America, of Babcock and Wilcox, Ltd., Babcock House, Farringdon-street, London, E.C.4.

MR. E. H. BALL, a director of Associated Electrical Industries Ltd., and managing director of the British Thomson-Houston Co. Ltd., has been elected chairman of Birlec Ltd., Tyburn-road, Erdington, Birmingham, 24. Also elected to the board are MR. W. W. VINSEN and MR. E. S. LITTLE.

MAJOR-GENERAL H. E. PYMAN, C.B., C.B.E., D.S.O., general officer commanding the 11th Armoured Division, B.A.O.R., is to be director of weapons and development, War Office, with effect from April, 1955.

MR. C. J. PRATT, A.M.I.Chem.E., A.M.I.P.E., A.I.I.A., has been made work-study and productivity officer, Association of British Chemical Manufacturers, Cecil Chambers, 86 Strand, London, W.C.2, as from January 3, 1955.

MR. R. T. BETTS, M.B.E., B.Sc., A.C.G.I., A.M.I.C.E., general manager, McCalls Macalloy Ltd., Templeborough, Sheffield, has been appointed a director.

MR. M. M. HALLETT has been appointed managing director of Chamberlin and Hill Ltd., Chuckery Foundry, Wallsall.

MR. NOEL LINDLEY, F.I.M., M.I.E.I., is leaving the Aeronautical Inspection Directorate to-day, December 31, after 38 years of service. His address will be "Far View," Brixham, Devon.

MR. E. H. UNDERWOOD, O.B.E., has been appointed director of public relations to the United Kingdom Atomic Energy Authority, Bedford Chambers, Covent Garden, London, W.C.2. MR. STANLEY WHITE is to be Press officer. Early in 1955 the Press office will move to St. Giles-court, St. Giles High-street, W.C.2.

MR. D. N. DE MATTOS, B.Sc., has been made subdistrict manager of the district office of the British Thomson-Houston Co., Ltd., Rugby, at 119 Victoria-street, Bristol, 1.

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BUSINESS CHANGES

VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, London, S.W.1, have announced the formation of three subsidiary companies, namely, VICKERS-ARMSTRONGS (AIRCRAFT) LTD., VICKERS-ARMSTRONGS (ENGINEERS) LTD., and VICKERS-ARMSTRONGS (SHIPBUILDERS) LTD.

The "Polford" range of foundry plant and equipment is now being manufactured by the POLFORD ENGINEERING CO. LTD., Heaton Junction, Newcastle-upon-Tyne, 6. The sole selling agents are THOS. W. WARD LTD., Albion Works, Sheffield. The directors of the new company are MR. C. W. COAN, chairman, and MR. G. POLLOCK, M.I.B.F., MR. S. K. EDWARDS and MR. G. R. CHETWYND, M.P.

ASSOCIATED BRITISH ENGINEERING LTD. are to acquire the whole of the issued share capital of BRITISH POLAR ENGINES LTD., and it is intended that the business of the firm be continued on the present lines. The Associated British Engineering Group will now comprise: The BERGIUS CO. LTD., BRITISH POLAR ENGINES LTD., HENRY MEADOWS LTD., A. C. MORRISON (ENGINEERS) LTD., and H. WIDDOP & CO. LTD. By the acquisition of British Polar Engines Ltd., the power range of the marine division of the Group will be greatly extended and will cover engines from 22 b.h.p. to 1,900 b.h.p.

DEGENHARDT & CO. LTD., are opening a CARL ZEISS agency in Great Britain at 32, Maddox Street, London, W.1., on January 5, 1955.

Obituary

SIR ERNEST LEMON, O.B.E.

Railways and Aircraft Production

We regret to record the death of Sir Ernest Lemon, which occurred on Wednesday, December 15, at the age of 70. He was well known in the railway world for his work on the Midland and London Midland and Scottish Railways and later as Director-General of Aircraft Production at the Air Ministry.

Ernest John Hutchings Lemon was born in 1884, and was educated at the Heriot Watt College, Edinburgh. He received his early engineering training at the Hyde Park Works of the North British Locomotive Company and, after serving for a time with Brown Brothers and Company, Limited, Edinburgh, he joined the staff of the Highland Railway at Inverness and was subsequently employed by Hurst, Nelson and Company, Limited, Motherwell.

He returned to railway work in 1911, when he was appointed chief wagon inspector of the Midland Railway Company. He became manager of the Derby works of that undertaking in 1917, at the early age of thirty-two, and when grouping took plate in 1923, he was appointed divisional carriage and wagon superintendent with the same headquarters, as well as being placed in control of the works at Newton Heath and Earlestown. In 1927, he became Carriage and Wagon Superintendent of the London Midland and Scottish Railway and four years later was promoted to be chief mechanical engineer in succession to Sir Henry Fowler. In 1932, he succeeded Lieut.-Colonel J. H. Follows as a vice-president of the Company.

During his railway career Lemon was actively engaged in the modernisation of the motive power depots and goods terminals of the L.M.S. He was also responsible for introducing continuous production methods into the construction of locomotives, carriages and wagons. He initiated the School of Transport at Derby and took a great interest in other courses of training. Schemes designed to improve the operating efficiency of the system were introduced under his direction and many train services were accelerated.

In 1938 he was seconded by the railway to the Air Ministry, where he served as Director-General of Aircraft Production with a seat on the Air Council. In 1940, he returned to the railway and a year later was appointed chairman of a Commission to consider the post-war planning and construction of the railways. In 1948 he was made chairman of a Government Productivity Committee.

Lemon was knighted for his services at the Air Ministry, having been appointed an Officer of the Order of the British Empire in 1918. He was elected a member of the Institution of Mechanical Engineers in 1929, and was also a member of the Institute of Transport.

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DR. G. F. C. SEARLE, F.R.S.

Physics at the Cavendish Laboratory

We record with regret the death of Dr. G. F. C. Searle, which occurred at Cambridge on Thursday, December 16, at the age of ninety. He was known to many generations of undergraduates as an enthusiastic, if rather awe-inspiring, teacher; to his co-workers in the Cavendish Laboratory as an ingenious experimenter; and to a wide circle of physicists as something of a character.

George Frederick Charles Searle was born at Oakington, Cambridgeshire, on December 3, 1864, and was educated privately. His first contact with physical science was, however, made during this period when in company with his father he was shown round the then newly opened Cavendish Laboratory by Clerk Maxwell. At the age of twenty he entered Peterhouse, Cambridge, as a scholar, becoming 28th wrangler in 1887 and obtaining a second class in Part II of the Natural Sciences Tripos a year later.

In the same year he began his long connection with the Cavendish Laboratory, being appointed assistant demonstrator under J. J. Thomson, with whom he collaborated in a research into the ratio of the electrostatic unit to the electromagnetic unit. The results of this work were published in the *Philosophical Transactions* of the Royal Society. In 1890 he became demonstrator in the laboratory and served as an examiner in physics in the Natural Sciences Tripos in 1898 and 1899. In 1900 he was appointed one of the university lecturers in physics. He was elected a Fellow of the Royal Society in 1905 and from 1917 to 1919 he served as technical assistant in the Royal Aircraft Establishment. He retired officially in 1935, although he continued his attendance at the Laboratory and was a demonstrator during the second World War, from 1940 to 1945.

Searle was the author of a number of books and papers of which perhaps the most important were the volumes on mechanics, the properties of matter, heat and optics, which were based on his laboratory work with students. One of his last appearances was at the celebration in 1950 of the centenary of the birth of Oliver Heaviside, when he gave a characteristically pungent account of his long acquaintaince with that "strange but, to some who were attuned to him, very attractive person."

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MR. ARTHUR SCRIVENER, M.C.

The Development of Centreless Grinders

With the death of Mr. Arthur Scrivener on December 14, a unique machine-tool business loses its energetic and inventive founder and managing director. Since 1932, when he established his own works and company (Arthur Scrivener, Limited) at Tyburn-road, Birmingham, he earned a well-deserved reputation for the design and manufacture of centreless grinding machines. His first machine of this type proving a success, he soon decided to concentrate on them and subsequently introduced many improvements, particularly in connection with automatic operation. His first patent, dated 1933, was for bearings for this type of machine and altogether he took out more than 40 patents for centreless grinders and other machine tools.

Arthur Scrivener was born in Birmingham on July 13, 1897. As a young man he gained practical experience in the shops and foundries of several local firms, though the first World War interrupted his engineering career. He joined up in 1914 in the Royal Warwickshire Regiment as a private; he was commissioned, was awarded the Military Cross, and reached the rank of Captain. After the war he joined the late Arthur Andrews, who was running a general machine-tool business in Birmingham, and when this business became a subsidiary of the B.S.A. organisation he remained to manage it.

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We regret also to record the deaths of:

DR. THOMAS WIGHTMAN CHALMERS, M.I.Mech.E., on December 22. He was for many years a member of the editorial staff of our contemporary *The Engineer*. We intend to publish a memoir in next week's issue.

MR. ALBERT VICTOR BELLAMY, in London on December 11, at the age of 48. Mr. Bellamy had been head of the publicity department of D. Napier and Son, Limited, for over 18 years. Before joining Messrs. Napier in 1936 he had been on the editorial staff of *Flight* and *Auto*.

MR. WILLIAM OLIVER GREY, in hospital at Carlisle on December 5, at the age of 81. Mr. Grey, who was born at Chorlton-on-Medlock, near Manchester, began a life-long association with Cochran & Co. (Annan), Ltd., boilermakers, Annan, Dumfriesshire, when he joined the firm, then in Birkenhead, as an apprentice. When the company removed to Annan in 1899, Mr. Grey came with them. He subsequently became assistant chief draughtsman, and in 1915 chief draughtsman. He retained this position until 1945 and finally retired in 1952.

CENTENARY OF THE CRIMEAN WAR

BIRTH OF ARMOURED IRON SHIPS

By Engineer Captain Edgar C. Smith, O.B.E., R.N.(RET'D.)

To some readers the days of the wooden warship and of the pioneers of armoured ships may seem very remote, but when I joined the Chatham Reserve in 1895 I messed in one wooden ship, slept in a second and got my orders from an office in a third, alongside which lay the "floating factory" Chasseur, while Crimean gunboats plied on the Medway. In 1900 I served under Admiral Seymour in North China and two years later was appointed an instructor at Dartmouth, where for three years I spent much of my time in the 120-gun ship Britannia, launched as the Prince of Wales, and in the 78-gun ship Hindostan, much of the oak and teak of which is incorporated in the London "Tudor" shop of Messrs. Liberty. After attending in August, 1905, the last prize-giving in the famous old training ship, I was sent to Bermuda and there, in the shelter of Ireland Island, was the Terror with the shipbreakers aboard. She had crossed the Atlantic in 1859, presumably under tow, and had long served as a depot ship. In 1905 the shipbreakers were removing the armour, the wrought iron for which had been made in puddling furnaces and the plates fashioned under steam hammers 50 years before.

The Russo-Turkish War, generally referred to as the Crimean War, in which France and Britain joined forces against Russia to preserve the integrity of the Ottoman Empire, lasted from the spring of 1854 to that of 1856. The first great war since the days of Napoleon, it was entered upon without due preparation and, in the words of Sir George Trevelyan, exposed the utter incompetence of the higher command, the lack of organisation and staff work, and the deficiency of commissariat and medical provision, forming a remarkable contrast to our commercial and industrial efficiency.

Fortunately the Navy was somewhat better prepared than the Army, but there were many lessons to be learnt and the experiences of those two years brought about a complete revolution in naval tactics and naval architecture. In spite of the progress made in steam navigation, hitherto the majority of naval officers and master shipwrights had never pictured the supersession of the great wooden three-decker as the principal fighting unit, but the war sounded the knell of both sailing ships and wooden ships for war purposes. From the naval point of view the war was unusual in that the Russian Black Sea Fleet, which, in November, 1853, had destroyed the Turkish ships in Sinope, withdrew to the shelter of the harbour of Sevastopol, while the Russian ships in the Baltic never challenged the British and French fleets.

The tasks of the combined navies were therefore not those of fighting at sea and maintaining the command of the oceans, but those of protecting transports, conveying troops, covering landing parties and bombarding fortifications. Just as many a regiment bears among its battle honours the names of Alma, Inkerman and Balaclava, so the battle honours of ships include the names of Odessa, Sevastopol, Kertch, Kinburn, Bomarsund and Sveaborg. Besides the campaigns in the Black Sea and Baltic there was also considerable activity in the White Sea and the North Pacific. At that time Alaska was still a Russian province.

ARMOURED FLOATING BATTERIES

Some idea of the growth of our naval forces owing to the war can be gleaned by recalling two reviews held at Spithead by Queen Victoria. In March, 1854, the Queen and Prince Albert inspected and watched the departure for the Baltic of the squadrons under the command of the veteran Admiral Sir Charles Napier (1786-1860), consisting of fifteen vessels all fitted with steam engines. Two years later Her Majesty held another review. This time there were no fewer than 240 vessels present. There were wooden sailing ships, wooden auxiliary-screw ships, wooden paddle-wheel frigates and corvettes, iron troop-ships, an ammunition ship, a hospital ship, a floating factory, numerous mortar vessels, some of which were self-propelled, over a hundred shallow-draught iron gunboats and also four "armoured floating batteries." Here was something entirely novel, for these included the Erebus, built on the Clyde by Robert Napier, and the Terror, built on the Tyne by Charles Palmer. These ships had iron hulls and iron armour 4½ in. thick. They were 186 ft. long, 48½ ft. wide, had a displacement of about 1,900 tons, engines developing about 400 h.p., and each carried 16 guns. Of some similar craft it was said that "they will neither sail, steam or steer," but the Erebus and Terror were the forerunners of Ericsson's Monitor and our own mastless Devastation.

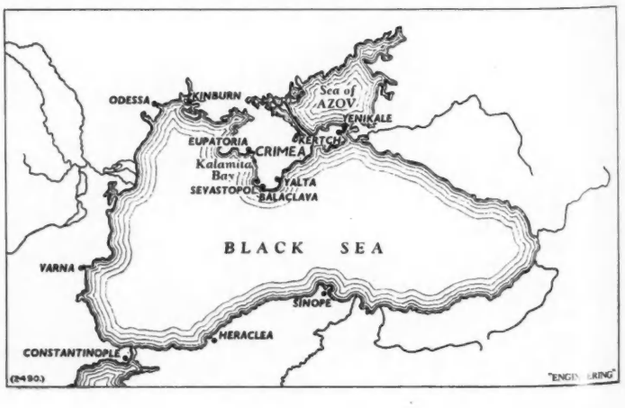
At the beginning of 1854 our Mediterranean Fleet included eight sailing line-of-battleships mounting a total of about 800 guns, two 50-gun sailing frigates, the 90-gun screw-ship Agamemnon, the 70-gun screw-ship Sans Pareil, and some 15 steam frigates and sloops, the finest of which was the Terrible, a paddle-wheel vessel of 3,000 tons and 2,000 h.p. with 16 guns. The Commander-in-Chief, who flew his flag in the 120-gun ship Britannia, was Vice-Admiral James W. D. Dundas (1785-1862), while the Second-in-Command was Rear-Admiral Sir Edmund (afterwards Lord) Lyons (1790-1858), whose flag was flown in the Agamemnon. Both in this ship and in the 121-gun screw-ship Royal Albert, to which the flag was transferred in February, 1855, Lyons had as his flag captain the progressive and capable Captain (afterwards Admiral Sir) William Robert Mends, and it is in his *Life*, by his son, that the reader will find a full account of the work of the Navy in the Black Sea. Mends was born in 1812 and died in 1897. As a flag lieutenant at Malta he studied steam under Thomas Hamshaw, who for 37 years was chief engineer of Malta Yard, and he was singularly free from the prejudices of many of his contemporaries. Another officer from whose memoirs something can be gleaned was Admiral of the Fleet Sir Edward Seymour, who, in 1854, was serving as a midshipman in the Terrible.

The first serious naval action in the Black Sea after the declaration of war was the bombardment of the busy port of Odessa on April 22. The action began about 6.30 a.m. and lasted till 4 p.m., the British paddle-wheel frigates Sampson, Retribution, Tiger, Furious and Terrible, and the French steam ships Mogador, Vauban and Descartes playing the leading part. "A pretty episode resembling olden days," wrote Seymour, "took place on the Arethusa, a 50-gun sailing frigate, standing in under sail and engaging the outer batteries, this being, I believe, the last time that an English man-of-war was ever in action under sail." On this occasion Mends was temporarily in command of the Arethusa. A few weeks later the Tiger had the misfortune to run aground under the Russian batteries and became a total loss.

50,000 MEN LANDED

While these things were happening the allied armies were assembling on the shores of Turkey and Bulgaria and early in September some 50,000 British, French and Turkish troops were taken aboard and were successfully landed at Eupatoria and Kalamita Bay to the north of Sevastopol, over 400 vessels being employed. The battle of the Alma was won on September 20. Six days later our ships took possession of the harbour of Balaclava, and on October 17 the first great bombardment of Sevastopol took place. A sketch of the plan of attack given in the *Life of Mends* shows six Russian ships sunk across the mouth of the harbour and the allied fleets disposed in an arc outside, with 17 British ships to the north and 13 French and Turkish ships to the south. It was on this occasion that our sailing line-of-battleships were towed into action by steam vessels lashed alongside, a practice long advocated but never before put to the test. With their superior manœuvring power the Agamemnon and Sans Pareil were able to engage the forts at short range, but both suffered severely. The log of the Agamemnon shows that she began firing about 1 p.m. and withdrew about 5.30 p.m. She had four men killed and 25 wounded, much of her rigging had been shot away, her sides and decks were ripped up by shell fire, she had twice been on fire and had 40 shots sticking in her sides. In a letter dated October 18, Mends began: "The plan of attack was as ill-contrived as could be," and towards the end wrote "Thus ended the naval attack upon Sevastopol for the present, nor do I think another will be tried, so futile are the efforts of ships against batteries, unless they can get very close to them . . ." It was nearly a year before the fortress fell to the allied armies.

Severely as some of our ships had suffered from fire from the forts, on November 14-16 the Fleet passed through the ordeal of a hurricane during which some forty vessels were lost; these including the French ship-of-the-line Henri Quatre, a Turkish ship-of-the-line and the new P. & O. Prince, a fine new iron steamer. In the Terrible the water flooded the stokehold, putting out some of the fires, but the situation was saved by the Chief Engineer Andrew Douglas lifting the stokehold plates so that the water could flow into the bilges, whence it was pumped by the air pumps of the main engines, which, like all engines at that time, had jet condensers. Describing his experiences in the Agamemnon, Mends wrote that "I soon had a third anchor down and kept the engines going to ease the cables which, thanks to James Watt, enabled the good ship Agamemnon to ride



The Black Sea, where naval operations a hundred years ago forced the development of naval architecture and marine engineering.

easily." On another occasion he wrote "The dear old screw is slowly working away to ease the cables and affords much comfort."

SUBMARINE TELEGRAPH CABLE

During the year 1855 the war proceeded with fluctuating fortunes, but there was always great activity around the coasts of the Crimea. The new mortar boats and shallow-draught gunboats began to arrive and there was an endless stream of transports and store ships. In January, Admiral Lyons succeeded Admiral Dundas as Commander-in-Chief and in February, with his staff, took up his quarters in the Royal Albert. In April, Mends records the laying by Captain (afterwards Vice-Admiral) T. A. Spratt (1811-88) of the Spitfire, of 300 miles of submarine cable which brought London and Balaclava into direct telegraphic communication. Spratt, who was the principal surveying officer in the Fleet, was afterwards elected a Fellow of the Royal Society.

The month of May saw the expedition to the Sea of Azov, when Kertch and Yenikale were captured with much machinery and some 12,000 tons of coal. Our shallow-draught gunboats then destroyed all Russian shipping in the inland sea, thus cutting off supplies for Sevastopol. The great fortress itself fell in September and then followed the allied attack on the forts at Kinburn at the mouth of the River Dneiper. Some 50 steam warships were engaged in this attack, including the three French wooden-hulled iron-armoured "floating batteries" Tonnante, Lave and Devastation. "They were," wrote Clowes, "the earliest armoured steam ships and their appearance in action marks the first beginning of perhaps the greatest revolution which has ever been experienced in the science of naval warfare." The forts at Kinburn were easily destroyed and after the action Mends wrote "The French floating batteries are perfect; the shot struck against them in many places, but simply indented the iron a trifle and shell broke against them as glass. It has been a good experiment; now Cronstadt and Sveaborg are doomed; nothing can save them." In this action, the French, for the first time in naval warfare, used searchlights with parabolic mirrors, the current for which was supplied by primary batteries.

While the memoirs of Mends and Seymour give an insight into the work of the Navy in the Black Sea, the *Life and Letters of Admiral Sir B. J. Sulivan* (1810-90) contains much about the ships in the Baltic. In 1854 Sulivan was in command of the little Lightning, the first steam vessel commissioned in the Navy. She was then employed on surveying but was sent to the Baltic. On reporting himself to Admiral Napier he was met with the remark that he "did not know what he had come out for, or what was the use of a surveying ship, unless to make a fire ship of." Napier was then 68 years of age and had lost the vigour of the days when he stormed at the Admiralty for their ignorance of the benefits of steam power, but the Lightning proved of great service and one of the illustrations in the *Life* of Sulivan shows her leading the Edinburgh, Hogue, Amphion, Blenheim and Ajax through the channels of the Aland Islands for the assault on Bomarsund, which was captured on August 15, 1854. In his letters, Sulivan refers to the coal question, the merits and demerits of ships, the health of the crews, and he emphasises the importance of a supply of fresh water. Another officer, Admiral Moresby, records how the aged Napier went aboard the Driver to make a reconnaisance but fell asleep in one of the chairs thoughtfully provided and that the engines were equally thoughtfully stopped till he awoke; no doubt a unique episode in naval engineering history. When next spring our ships again left for the Baltic they were under the command of Rear Admiral Richard Saunders Dundas (1802-61).

MAINTENANCE OF MACHINERY

The employment of numerous steam vessels of various types in warfare raised many problems, among which was the maintenance of the machinery of both warships and transports. There were no dockyards available in the Black Sea and Baltic and this led to the appointment as Inspector of Machinery on Admiral Lyons's staff of Thomas Baker, whose whole career had been passed in the Service and who for a long time had been chief engineer of the Royal Yacht Victoria and Albert. From evidence Baker gave before a committee in 1858 it is learnt that workshops were erected at Kazatch Creek, to the west of Sevastopol, that lathes and forges were landed from ships; boilers, engines and tools obtained from Kertch; mechanics sent out from Woolwich and Portsmouth; and another workshop set up at Constantinople.

At Baker's suggestion the Admiral applied for a "floating workshop," but though nothing came of this the War Office sent out the converted collier Chasseur, equipped with tools and in charge of the youthful but vigorous Robert Samuel Fraser (1829-83). The Chasseur reached Balaclava in September, 1855, and proved of great value to both the Army and Navy. After the war her name appeared in the Navy List. While Baker was busy with repairs in the Black Sea, Chief Engineer John Ward was similarly employed in the Baltic, to which our first repair ship was sent. Ward's evidence in 1858 shows that he had to deal with various defects such as broken pistons and slides, bent rods and defective shafts.

STERN-GLAND WEAR

In many screw-ships, especially those with lifting propellers, a common defect was the rapid wear of the stern shaft and propeller bearings, a defect which it was beyond the capacity of any repair ship to remedy, and one which sometimes restricted the use of the engines. Naval vessels had their iron stern shafts fitted with brass sleeves which ran on brass bearings. The rapid wear of these bearings, combined with the vibration of the screw and the working of the ship's timber in a seaway occasionally led to serious trouble. A remarkable example of this was seen in the Royal Albert when on passage from the Black Sea to Malta in December, 1855, when, through the rapid wear at the stern, water poured into the ship through the stern gland. To save her she was beached bow first on an island in the Aegean while the carpenters built a cofferdam inside the ship. For four days she lay beached, the main engine, like the Terrible's, being used to keep the water down. A model of this cofferdam was preserved at Greenwich. It was John Penn who, in 1854, solved the problem of the stern-tube bearing by the use of lignum vitae as we have it to-day, one of the first ships fitted being H.M.S. Himalaya, the finest iron steamer afloat, which had been built for the P. & O. and taken over by the Admiralty as a transport.

Another problem of the day, when consumption per horse-power was high and stowage small, was the supply of coal. At the beginning of the Crimean War coal at Constantinople was 65*s.* a ton, but through a visit of the officers of the Spitfire to mines at Heraclea in Asia Minor, arrangements were made for coal to be carried by mule to the coast at abou 20*s.* a ton. Baltic ships, with the exception of the flagship the Duke of Wellington, used North Country coal, the smoke from which while ships were in action or passing through narrow channels proved intolerable. The flagship however was supplied with Welsh coal and so were some of the French ships, and the gradual replacement of North Country coal by Welsh coal was largely due to the efforts of John Nixon (1815-99), the pioneer of the Welsh coal industry. It was he who persuaded the French Navy to use it and for many years engine-room registers in the Royal Navy contained the words "Nixon's Navigation."

ROYAL DOCKYARDS

There was great activity in the British yards during the war. In 1854 there were no fewer than 40 wooden vessels, great and small, under construction in the seven Royal Dockyards, Pembroke alone having 12 in hand. Equally great was the activity in the marine-engineering shops at Lambeth, Greenwich, Deptford and Millwall. The Thameside works had almost a monopoly of naval engineering work. Penn's beautiful oscillating paddle-wheel engines and horizontal trunk engines were admired by all but were rivalled by Maudslay's "Siamese" engines, as seen on the Terrible, and their horizontal return connecting-rod engines. The Duke of Wellington was one of the few ships not engined on the Thames. Of 6,000 tons and 2,500 h.p., her engines were built by Robert Napier. These had two horizontal cylinders, nearly 8 ft. in diameter, 4½-ft. stroke, driving a spur wheel 10½ ft. in diameter which geared into a wooden-toothed pinion 4½ ft. in diameter and nearly 4½ ft. wide on the propeller shaft. At this time boiler pressures were seldom over 20 lb. per square inch.

STANDARDISATION AND MASS PRODUCTION

The capacity of both yards and shops was put to the test when it was decided to build mortar boats, floating batteries and more than a 100 shallow-draught gunboats. The last were given high-pressure non-condensing engines. Penn, being consulted as to the supply of machinery, adopted the methods of standardisation and mass production, distributing patterns of the various parts of the engines to different firms and assembling the engines at Greenwich. Much the same was done by Maudslay's at Lambeth, who during 1854–56 supplied the Navy with about 90 sets of machinery. Penn's list ran to 120 sets. Other well-known marine engineers on the Thames were Miller and Ravenhill, Seaward and Capel, J. and G. Rennie, and Edward Humphrys, the founder of Humphrys and Tennant of Deptford.

Though the war had shown the unsuitability of sailing and wooden ships, it was not to be expected that old and established practices would be readily abandoned, and for at least five years after the war, the British Admiralty, and for a long period the French Authorities, continued to construct wooden ships, some of which, however, were armour-plated. In any case, whatever was done the work of the Navy could not be carried on with craft like the Erebus and Terror, and naval architects had to work out designs for sea-going iron ships. Then, too, by no wave of a wand could sawyers and shipwrights be turned into platers and riveters. So it came about that our largest wooden ship, H.M.S. Victoria, was not launched until 1859. With a displacement of about 7,000 tons she had engines of 4,200 h.p., carried 121 guns and a complement of 1,120 officers and men. In her and her sister ships, said Sir William White, "was embodied not merely the accumulated experience of centuries in hulls, rigging equipment and armament, but that of nearly half a century of marine engineering."

Obsolescent when completed, the Victoria yet served as flagship in the Mediterranean from 1864 to 1867. By that time Napier had built the iron-hulled iron-armoured frigate Black Prince of 6,000 tons and 5,000 h.p., her sister ship the Warrior had been built at the Thames Iron Works, and with the laying of the keel of the Achilles (6,000 tons) at Chatham, in 1861, iron-shipbuilding was begun in the Royal Dockyards. Moreover, by the sixties, John Brown had shown how armour plates could be rolled instead of hammered; Krupp, Armstrong, Whitworth and others were revolutionising the making of guns; marine engineers were talking of high-pressure boilers, compound engines and surface condensers; and in his inaugural address to the Institution of Naval Architects, Dr. Woolley said that "it was essential for naval architects to drink deeply of the well of scientific truth and to be imbued largely with the spirit of philosophical enquiry." The effect of the war on technical advances was far-reaching and partly to its influence can be traced the foundation of the Institution of Naval Architects in 1860, and that of the Royal School of Naval Architecture and Marine Engineering at South Kensington, London, in 1864.

INCREASED PRODUCTION OF EPIKOTE RESINS

USES IN SURFACE COATINGS AND PLASTICS

A new plant at Stanlow, Cheshire, will produce synthetic "Epikote" resins at the rate of 1,000 tons per year from the middle of 1955. The plant is being built for the Shell Refining and Marketing Company, Limited, Shell Court, White Kennett-street, London, E.1, and will augment the supply of Epikote resins from the plants in Holland and the United States. Epikote resins were first produced in 1949 in the United States, and since then an increasing number of uses has been found for them. The resins are of six grades, four solid and two liquid; they are reacted with curing agents in four main ways to give products which are tough, flexible, adhesive and chemically resistant, and which are particularly suitable for the surface-coating and plastics industries. For surface-coating applications the choice of a curing agent can vary the curing conditions from normal air-drying to short-time high-temperature stoving.

Some of the surface-coating uses for Epikote resins are in paints, lacquers, stove enamels, varnishes, floor coatings and printing inks. The resins form coatings which are hard, not easily marred, and not impaired by the most severe bend or bump tests. When applied to furniture, for example, they give protection against wear and tear, corrosive chemicals, alcohol, and even neglected cigarette ends. Food tins and similar containers can be painted with these materials, crushed before consignment to save storage space in dispatch, and expanded and re-formed at their destination with undamaged surfaces. Epikote-based coatings have been used very satisfactorily in chemical plant, where their resistance to chemical attack has proved most valuable. These coatings have so far taken the form of paints mainly for industrial use, but paint manufacturers are now producing Epikote-based paints for domestic use.

So far, it has been largely in the surface-coating industry that Epikote resins have been used, but in the plastics industry four main lines of use are developing. First, they have been employed as casting resins, formed into dies for making parts in the automobile and light-metal industries; the advantage they present here is mainly economic, because the dies are cheaper to make from Epikote resins than by conventional methods. Second, they are used as stabilisers for vinyl resins; these, especially polyvinyl chloride, need the addition of stabilisers to check the decomposing action of heat and light. The Epikote resins are acid acceptors and form the basis of certain proprietary stabilisers. Third, they are used in the "potting" technique for electrical circuits; the electrical assembly is surrounded with a liquid resin which is then cured to give an encapsulated product. Components protected in this way are robust and are not affected by humid conditions.

Fourth, they can be combined with glass fibres in the production of laminates which have high structural strength and chemical resistance. Such laminates are of special value for the construction of piping and equipment to handle corrosive materials. With a suitable resin formulation it is possible to make laminates that do not show any serious falling off in strength at temperatures as high as 250 deg. C. Another promising field for the use of Epikote resin adhesives is as hot or cold setting compositions; they have been developed particularly for applications where high-strength metal-to-metal bonds are required, as in the aircraft industry.

CHEMISTRY OF EPIKOTE SURFACE COATINGS

The basic materials for Epikote resins are epichlorhydrin and diphenylolpropane; epichlorhydrin is produced by Shell, and is made from propylene, chlorine and a caustic solution; diphenylolpropane is made from phenol and acetone, the latter also a product of the petroleum chemical industry. Epikote resins are made by heating a solution of diphenylolpropane in caustic with epichlorhydrin in a stainless-steel boiler equipped with a powerful stirring device. Solid or liquid resins can be produced by varying the proportions of the materials used. The four main methods of using Epikote resins for surface coatings are as follows: by combination with other synthetic resins, such as phenolic or amino resins, to produce stoving finishes; by curing with amines to produce cold-cure or stoved coatings; by esterification with drying oil fatty acids to produce air-drying and stoving finishes; by esterification with drying or non-drying oil fatty acids used in conjunction with amino resin, to produce stoving finishes.

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HYDRO-ELECTRIC POWER IN ONTARIO

Consequences of Frequency Standardisation

The almost continuous progress of the Hydro-Electric Power Commission of Ontario received no check in the year 1953, when the kilowatt-hours of energy produced exceeded those of 1952 by 4·7 per cent. It is necessary to go back some twenty years or more to find any record of a fall in energy production between one year and the next. The curve of output has risen very steeply in the last five or six years, particularly on the Southern Ontario System which serves the most populated and highly-developed part of the Dominion. Immediately after the end of the war, a great expansion programme was inaugurated and although it is not yet completed, the generating capacity at the end of 1953 was 84 per cent. greater than that of 1945. The Commission now owns or operates 64 water-power stations and six thermal stations.

The dependable peak capacity of the Commission's stations increased by 6·3 per cent. in 1953, the total at the end of that year being 4,779,300 h.p., as compared with 4,495,100 h.p. at the end of 1952. A main addition during the year was the installation of the eighteenth and final unit in the Otto Holden Generating Station on the Ottawa River, bringing the dependable peak capacity up to 282,000 h.p. This completed the Commission's development work on the Ottawa River, which forms part of the boundary between Ontario and Quebec. Since 1945, 951,000 h.p. has been harnessed by the Commission on this river. Further important developments were the completion of the third and fourth units of the J. Clark Keith steam station at Windsor on the Detroit River making the total capacity 354,000 h.p., and the installation of a fourth unit in the Richard L. Hearn steam station at Toronto, bringing the total capacity up to 536,000 h.p.

Although it did not contribute to the total output in 1953, mention should be made of the Sir Adam Beck Generating Station No. 2, as it is dealt with at some length in the Commission's report for that year. The station which was officially opened by the Duchess of Kent on August 30, 1954, is situated below the Niagara Falls and alongside the Sir Adam Beck No. 1 station. This latter has a 20-minutes dependable peak capacity of 317,000 kWh, and generated 2,675,675 MWh in 1953. No. 2 station is designed for an ultimate capacity of 1,828,000 h.p. and will incorporate a pumped-storage system. This latter feature is being introduced in order that restriction in the use of water which may occur under the Niagara Division Treaty shall not prevent full operation of the station. Although Canada is remarkably rich in water-power resources, the vagaries of the weather at times cause difficulties and in the second half of 1953, unusually low flow of the Ottawa River necessitated increased output from the steam stations in Toronto and Windsor.

During the last five years, the Commission has been engaged on a frequency-standardisation programme, the areas supplied at 25 cycles being changed over to 60 cycles, the frequency adopted as standard. Increased supply at the new frequency has been provided for by re-winding some of the units in the Toronto steam station and interconnecting with the 60-cycle system of the Detroit Edison Company by means of transmission lines crossing the Detroit River. The change-over in some municipal systems and rural areas has been facilitated by the temporary installation of frequency-changing plant. The extent of the work involved at the consumers' end in changing the frequency is shown by the fact that up till December 31, 1953, 1,357,824 appliances in domestic consumers' premises had been attended to, and 101,102 clocks, fans and other small appliances had been exchanged for new ones. In commercial consumers' premises, 236,285 items of equipment were changed over and 331,621 motors were rewound. Although each item in this extensive programme may be small, the total work involved is immense and demands careful organisation. The Commission itself operates a rewind shop and has made working arrangements with a number of manufacturing firms. The provision of dual-frequency equipment has also been encouraged.

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Contracts

TONNAGE OXYGEN PLANT

THE BUTTERLEY CO. LTD., Butterley, near Derby, have secured a contract from Stewarts and Lloyds Ltd., for a large tonnage oxygen plant to be installed at the Corby Iron and Steel Works. The plant will be to the design of Air Products Inc. of Allentown, Pennsylvania, U.S.A., from which firm the Butterley Co. hold the manufacturing rights for Great Britain, certain European countries and the British Commonwealth. It will be capable of producing 200 tons of 99·5 per cent. purity oxygen a day. The plant will be used in connection with the large increase in output of steel planned by Stewarts and Lloyds. The value of the contract is over £300,000.

Railway Wagons.—The British Transport Commission have placed a contract with the TEES SIDE BRIDGE AND ENGINEERING WORKS LTD., Middlesbrough, for 300 bogie bolster wagons of 42-tons capacity.

Electrical Equipment for Atomic Energy Authority.—LAURENCE, SCOTT AND ELECTROMOTORS LTD., Gothic Works, Norwich, inform us that they have been authorised to announce that they have received a contract from the United Kingdom Atomic Energy Authority for electrical equipment to a value exceeding £400,000. Delivery will begin in the middle of 1955 and will continue for some time after.

Radio Equipment.—A contract has been signed between the Imperial Board of Telecommunications of Ethiopia and STANDARD TELEPHONES AND CABLES LTD., Connaught House, Aldwych, London, W.C.2, and MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, for a new international radio communications system, working from Addis Ababa. The system will provide radio telephone and telegraph communication with London, Nairobi, and important centres in the Middle East. Additional services may be inaugurated later to other European centres.

Equipment for Electric-Car Sheds.—A contract for electrical equipment for the electric-car sheds at Gosforth, Newcastle-upon-Tyne, has been placed by the North Eastern Region of British Railways with the GENERAL ELECTRIC CO. LTD., Witton, Birmingham, 6.

BOOK REVIEWS

Engineering for Agricultural Drainage. By PROFESSORS HARRY BURGESS ROE and QUINCY CLAUDE AYRES. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7·50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (60*s.*)

Land drainage is a very ancient activity. Herodotus, in 400 B.C., referred to works in the Nile Valley, and, in this country, the long history of the drainage of the Fens had its beginning during the Roman occupation when a drainage canal was constructed between what are now Lincoln and Ramsay; some regulation of the River Welland was also undertaken. Early activities were largely concerned with improving river channels and inaugurating drainage work in low-lying areas with the aim of preventing flooding. The Catchment Boards set up under the Land Drainage Act of 1930 were largely concerned with similar projects. From the first, however, the drainage of particular fields or areas was undertaken in order to render heavily moisture-laden soils suitable for the growing of crops. The Romans employed open trenches lined with brushwood or stones and drains of this type are common throughout the world to-day. The use of buried watercourses was introduced in this country somewhere about the beginning of the Nineteenth Century, and since that time special methods and special machines have been devised to increase the effectiveness of underground drains and to facilitate their construction.

In view of the insistence being now laid, almost throughout the world, on the importance of increased food production, this voluminous work is likely to have a wide appeal.

Rendering uncultivated land suitable for carrying crops may, in many cases, involve the clearance of tree stumps and bushes, the introduction of artificial irrigation, or the retardation of run-off. Operations of this kind are not, however, dealt with in this book, which is restricted solely to the question of drainage. Every aspect of this is treated; the early chapters are concerned with the properties of soils and the factors influencing the rate of infiltration, and also with questions of rainfall and run-off, and the measurement of water flow. These matters have direct bearing on drainage problems as any measures undertaken must have proper relation to the intensity of rainfall and its distribution in time. The book is only concerned with American conditions, but its treatment of drainage methods, which occupies the main part of the volume, is likely to prove of value in any country.

The basic purpose of agricultural drainage may be said to be the control of the elevation of the water table within the root zone of crops. This postulate accentuates the attraction of underground drains, but in some impermeable soils they may be less effective than open ditches; this emphasises the importance of relating drainage procedure to the nature of the land being treated and may well direct attention to the relevance of the early section of this book dealing with soil types. In the course of the chapters dealing with open ditches and underground drains it is stated that the only advantage of the former is their relative cheapness; they occupy more land than buried drains, require constant maintenance and are " usually neglected " so that they become choked with mud or vegetal growth. They frequently also interfere with farm operations. Buried tile drains are stated to be permanent if good tile is used and to " grow more efficient year by year." These observations require that emphasis should be laid on the adjective " good." Clay tile should exhibit low moisture absorption if it is to be subjected to alternate freezing and thawing, but this consideration is probably of more importance in some parts of the United States than in this country. Concrete drain tiles may be satisfactory in this respect, but subject to attack by acid or sulphate-bearing soils.

The authors of this book would appear to hold unfavourable opinions about mole drainage. They state that the life of mole drains is short and that their successful use is possible only in soils with strong cohesion under compression, and that they are " ill-suited for extensive use in the United States." These opinions are presumably dictated by the average type of soil found in that country, as mole drains have been widely and successfully used in this country and in New Zealand. In a paper read before the Institution of British Agricultural Engineers in 1946, Mr. E. A. G. Johnson, of the Ministry of Agriculture, stated that of the 4,000,000 acres lying on the clay formation of this country, at least 1,000,000 were in need of drainage at the commencement of the war. " Mole drainage provides the quickest and cheapest method for draining these lands." Mole drainage has the incidental advantage of helping to aerate heavy soils.

Various special machines and methods have been devised for mole drainage. These are not described in this book but machines for digging ditches and trenches for underground drains are dealt with. The sections of the book which deal with these machines are those of most direct mechanical-engineering interest. Many American machines have been used in this country, but others have been developed by British firms; the Priestman dragline designed for digging and clearing farm ditches is described and illustrated in this book. Various American trenching machines have been employed in Great Britain, but in general American plant has been designed to dig trenches rather larger than is necessary for field work here. British trench diggers have been introduced by a number of firms including, Priestman Brothers and Aveling-Barford.

Jane's All the World's Aircraft, 1954-55. Compiled and edited by LEONARD BRIDGMAN. *Sampson Low, Marston and Company, Limited*, 25 *Gilbert-street, London, W.*1. (84*s.*)

In the preface to this edition (the 45th) of *Jane's All the World's Aircraft*, the compiler's brief review of aeronautical progress during the year throws interesting light, among other things, on the relative advances in Great Britain and the United States. Whereas in the United Kingdom re-equipment of the Royal Air Force with high-speed subsonic fighters began only this year, the United States Air Force are already taking delivery of North American Super Sabre F100 fighters, the prototype of which exceeded Mach 1 in level flight over a year ago; and the position is rather more marked in the respective naval air forces. In civil aircraft, however, the success of the British Viscount propeller-turbine air-liner has no parallel in the United States, but several military turbo-propeller transports are now under development in America, in addition to the Boeing 707 jet transport ordered by the U.S.A.F. as a tanker transport.

Concerning Russian aircraft, it is stated that reliable data is still scanty. Much new information has, however, been added to this section, including a provisional description and drawings, but no performance details, of the four-jet heavy bomber which flew over Moscow on May Day this year. It is reported that the first post-war aircraft of German design, the Dornier DO25 light general-purpose monoplane powered by a 150-h.p. ENMA Tigre engine, has been constructed by the Dornier organisation in Spain (Oficinas Technicas Dornier.)

Most of those involved in any way in the aircraft industry will be familiar with the layout of this indispensable, authentic and profusely illustrated reference book. Briefly, the main portion of the book is divided into three sections giving technical details of the aircraft, engines (subdivided into gas turbines and piston engines), and airships (a very small section), respectively, of the manufacturers of each country, set out in alphabetical order. The aircraft section includes a chronological list of first flights made by new aircraft during the year. A useful feature of the indexes to these sections is that they include references to every aircraft and engine described in the previous editions published since the second World War. In addition to these three main sections are sections on military aviation (aircraft markings of the air forces of the world) and civil aviation including route and fleet information on the airlines of every country, official world records, and details of international aviation organisations.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Spectrographic Apparatus. HILGER AND WATTS LTD., Hilger Division, 98 St. Pancras-way, Camden-road, London, N.W.1. Illustrated description of three-meter grating polychrometer with direct photo-electric recording of spectrum-line intensity, designed for rapid routine spectro-chemical analysis. A typical determination occupies only three or four minutes. Accessories for infra-red spectrophotometry are illustrated and described in a separate catalogue.

Trench Pump. CLIMAX ROCK DRILL AND ENGINEERING WORKS LTD., 4 Broad Street-place, London, E.C.4. Pump driven by compressed air motor; suitable for water, oils, sewerage, waste liquids; single or double stage, capacities respectively 80 and 135 gallons per minute against 70-ft. head of water. Illustrated leaflet.

Coal and Ash Handling. MARCO CONVEYOR & ENGINEERING CO., LTD., Leytonstone, London, E.11. Mechanical stokers, conveyors and elevators for coal and ash handling. Illustrated brochure shows layouts, types available and performance figures.

Industrial Switchboard Instruments. MEASURING INSTRUMENTS (PULLIN) LTD., Winchester-street, London, W.3. Moving-coil or moving-iron ammeters, voltmeters or dynamometers for industrial switchboards. Illustrated catalogue section B (revised).

Band Conveyor. A. L. MARSHALL, LTD., Carlton, Nottingham. ALM " Masterveyor " made in standard 12-ft. units, electrically driven, adjustable band height, variety of band types and widths. Illustrated leaflet.

Boring and Facing Lathes. CROWTHORN ENGINEERING CO., LTD., Reddish, Stockport, Cheshire. 30-in. and 36-in. lathes with 4-way multi-position turret toolpost; wide range of additional equipment available. Illustrated leaflet.

Inspection of Inaccessible Parts. FOSTER INSTRUMENT CO., LTD., Letchworth. " Introscopes " for internal inspections; details of lengths and diameters for some standard models. Illustrated leaflet.

Theory of Variable-Speed A.C. Commutator Motors. BRITISH THOMSON-HOUSTON CO., LTD., Rugby. Theory of the Schrage motor from first principles; suitable for lecturers or tutors. Illustrated booklet written by A. C. Lane, B.Sc., A.M.I.E.E.

Petrol and Diesel Engines. PETTERS LTD., Causeway Works, Staines. Petrol, Diesel and vaporising oil engines 1½-20 b.h.p.; air compressors and marine auxiliary sets; brief specifications and technical data. Illustrated booklet.

Hammer Drill. CLIMAX ROCK DRILL & ENGINEERING WORKS, LTD., 4 Broad Street-place, London E.C.2. RV 200 hand hammer drill, stroke 1$\frac{11}{16}$ in., bore 2 in.; brief specification. Illustrated leaflet.

Spherical Plug Cocks. SAUNDERS VALVE CO., LTD., Cwmbran, Newport, Mon. Saunders " M " cock in six sizes from ½ in. to 2 in., suitable for wide range of fluids. Illustrated leaflet.

Alloy-Steel Castings. B.S.A. TOOLS LTD., Mackadown-lane, Birmingham 33. Castings for jigs, tools and dies, with typical examples. Illustrated leaflet.

Soldering Tool. C. I. CASEY LTD., 49 St James's-street, London, S.W.1. " Solo " lightweight electric soldering tool, description and instructions for use. Illustrated leaflet.

Metal Washers. HERBERT TERRY & SONS, LTD., Redditch. " Belleville " washers, internal diameter 0·328 in. to 0·516 in. Illustrated pamphlet, with load-deflection graphs.

Turret Drilling Machine. SOAG MACHINE TOOLS, LTD., Juxon-street, London, S.E.11. " Stellamatic," Model RB2, enabling six operations to be performed at one setting. Illustrated leaflet.

Engraving Cutter. EUCO TOOLS, LTD., 44 London-road, Kingston-on-Thames. " Karbo " tungsten-carbide engraving cutter. Leaflet.

BOOKS RECEIVED

Machine Drawing and Design. By DR. W. ABBOTT, C.M.G. Sixth edition. *Blackie and Son, Limited, 17 Stanhope-street, Glasgow, C.4.* (15*s.*)

This book, originally produced some years ago and now rewritten, is intended to provide an intermediate course in machine drawing and design for students of mechanical engineering who are following university and technical college courses, or are preparing for the examinations of the professional engineering institutions. The inclusion of representative designs and of standard data also renders the book of some service to draughtsmen and others engaged in engineering practice. Some knowledge of mechanics and strength of materials is assumed.

Proceedings of the Sixth British Electrical Power Convention, 1954. *Lea and Company, Ltd., 15 Broad-street, Northampton.*

This book contains a complete account of the proceedings at the British Electrical Power Convention, which was held at Eastbourne from June 14 to 18, 1954. It includes the five papers which were read in full and the discussions upon them, as well as details of the Electrical Forum and of the business at the Annual General Meeting. It is issued free to delegates and visitors of whom a list is given.

Radio and Television Engineers' Reference Book. Edited by E. MOLLOY. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.2.* (70*s.*).

This is the first edition of this reference book which has been written to bring together information required by engineers, technicians, radio amateurs and all who are engaged in the design, maintenance, technical sales, operation and servicing of modern radio and television transmitting and receiving equipment. The book is arranged in 45 main sections, each dealing with a specific branch of the subject and written by an authority in that field.

Technical Report of the British Engine Boiler and Electrical Insurance Company, Limited. New Series, Volume II. *British Engine Boiler and Electrical Insurance Company, Limited, 24 Fennel-street, Manchester 4.* (12*s.* 6*d.*)

This report follows closely on the lines of the previous one, consisting mainly of a selection of interesting service failures that have been investigated. It has not been practicable to continue the research into notched-bar testing, the early results of which were reported in the preceding volume, but it is hoped that this work will be resumed in the future.

Radioisotope Conference, 1954. Volume II: Physical Sciences and Industrial Applications. Edited by J. E. JOHNSTON. *Butterworths Scientific Publications, 88 Kingsway, London, W.C.2.* (45*s.*)

The Second Radioisotope Conference, organised by the Atomic Energy Research Establishment, Harwell, was held in July, 1954. Its object was to discuss the latest experimental uses of radioisotopes and new techniques in their application to medicine, biology, agriculture, chemistry and physics, as well as to engineering and other industries. The papers which were read, and their ensuing discussions, are published in two volumes. The first volume covered the application of radiosiotopes to medicine, agriculture and the biological sciences.

Timber Industry in Europe. Organisation for European Economic Co-operation, 2 *Rue André-Pascal, Paris 16e.* (6*s.*)

This report has been prepared by the Timber Committee of O.E.E.C. Chapters on the trend of the timber market in 1953 and short-term and medium-term forecasts are prefaced with a general outline of the structural elements of the timber market. A brief historical survey gives the salient facts which led up to the present structure, and some space is devoted to technical problems and more specific aspects such as international co-operation at trade level.

The Heat Pump and District Heating. By V. A. CARPENTER. Modern Science Memoirs No. 32. Published for the Science Masters' Association by *John Murray, Albemarle-street, London, W.1.* (2*s.*)

This booklet is divided into two parts, the first being devoted to the heat pump and the second to district heating. The principle and theory of the heat pump are stated and some existing installations, both in this country and abroad, are described. In the district heating section, the general advantages are laid out for the use of waste heat from power stations. Methods of distribution are outlined and various schemes now in progress are mentioned, particularly that at Pimlico.

POWDER METALLURGY

A SURVEY OF RECENT ADVANCES

A two-day Symposium, organised by the Council of the Iron and Steel Institute, in association with the Institute of Metals, was held in London on December 1 and 2, to survey the advances made in the science and practice of powder metallurgy since a first Symposium held in 1947. *The programme included* 50 *papers,* 38 *from the United Kingdom, arranged in four groups devoted mainly, at the request of the organising committee, to progress in research and development. Group* 1 *dealt with the manufacture, properties and testing of powders; Group* 2 *with the principles and control of compacting and sintering; Group* 3 *with the manufacture and properties of structural-engineering components and Group* 4 *with the powder metallurgy of high-melting-point materials.*

1.—MANUFACTURE, PROPERTIES AND TESTING OF POWDERS

The availability of adequate supplies of raw materials of the right quality is a vital matter to existing and potential manufacturers of sintered components. Dr. W. D. Jones (Powder Metallurgy, Limited), in an authoritative review "Metal Powders for Engineering Purposes," describes methods of manufacturing powders for application in engineering components and discusses the relative properties of the powders on the basis of (i) iron (ii) ferrous alloy, (iii) non-ferrous powders. Although a number of new principles have been applied in manufacture, the most striking developments since 1947, comprise cheaper methods of making base-metal powders, since the price of metal powders sets a restricting limit to the development of powder metallurgy. Some of these developments involve no more than improved "house keeping" but it is significant that new methods have emerged for producing powder as an end product in the process of extracting a metal from its ore.

IRON POWDERS

Large-scale ferrous powder metallurgy has been internationally dependent for its raw material on sponge-iron powder made by the Höganäs Company in Sweden, but new competitive methods have arisen since the war of 1939–1945. To obtain some idea of the scale of operation in the United States in the manufacture of sintered engineering components, the total consumption of iron powder in 1953 was about 11,500 tons, 7,000 tons (probably mainly Swedish sponge-iron) being imported, and the remainder of 4,500 tons being manufactured by the American Companies (Pyron, Plastic Metals, the Easton Metal Powder) and one Canadian Company (Ferrum).

Swedish sponge powder is produced in the Höganäs process by the reduction of magnetite concentrates packed in ceramic containers, using a mixture of coke or anthracite breeze and coal dust as a reducing agent. The Company have access to relatively pure magnetite concentrates, have their own coal and coke supplies, and manufacture ceramics. The powder finds wide application because (1) it is relatively pure (2) it is porous and possesses good pressing characteristics, (3) it is cheap to manufacture. Since 1947, newer grades, believed to be prepared by treating the normal powder with hydrogen, and possessing improved properties, have been introduced. In order to better supply the United States market, the Höganäs Company have recently completed a new plant with an initial capacity of 30,000 tons per annum at Riverton, New Jersey.

"RZ" Atomised Iron Powder was developed by Dr. Naeser of Mannesman Röhren Werke about 1942. In the United States, this process has been recently adopted in a new plant erected by the Easton Metal Powder Company, Pennsylvania. Liquid cast iron, low in sulphur and silicon, is atomised and dried in the course of which the powder becomes oxidised. The process is controlled in such a manner that enough carbon occurs in the iron to reduce the oxides present during subsequent heating, so that a relatively low-carbon pure-iron powder is obtained.

The Ferrum process consists in heating together high-carbon powder and iron oxide. The product is a mixture of particles of high density and low microporosity with particles of low density and high microporosity. Details of the physical properties of the powders are not available.

Selected mill scale is reduced in the Pyron process by means of hydrogen. This powder is popular in the United States, and has the advantage of developing slight shrinkage when mixed or infiltrated with copper—for this reason it is frequently mixed with other iron powders for the purpose of reducing expansion.

A reduction process involving carbon and hydrogen in consecutive stages of reduction is used by the Plastic Metals Division of the National Radiator Company, Johnstown, Pennsylvania. This grade of powder finds some acceptance in the United States. An electrolytic grade is produced economically by the same company and, as well known, is particularly suited for the manufacture of high-quality sintered components, especially those of high density and high strength by the technique of double pressing and sintering. In Europe, the principal producer of electrolytic iron is the Husqvarna Vapenfabrik, Sweden, and the material is used by them for a substantial production of high-tensile components based on a technique of double pressing and sintering. The product is very pure and results in low die-wear and compacts of high green strength.

In the United Kingdom, Swedish sponge iron is marketed by Powder Metallurgy, Limited, and both atomised and electrolytic iron are manufactured by the New London Electron works and electrolytic iron will also be manufactured by the Plessey Company under licence from the Husqvarna Organization. Data on the mechanical properties of compacts prepared from some of these typical powders have been collated (Table I) from various parts of Dr. Jones's paper.

It will be seen that low-density components would possess a tensile stress of about 13,000 lb. per square inch and an elongation of 5·5 per cent., whereas high-density parts produced by a double-cycle technique and consequently more expensive, would be much stronger with a tensile strength of 37,000 lb. per square inch and an elongation of 21·5 per cent. One point is outstanding. No one powder is acceptable for all engineering applications and selection is often governed by local or national interests. From the numerous recipes known to be used in industrial manufacture, it is obvious that even a powder metallurgist still likes to back his own fancy.

FERROUS-ALLOY POWDERS

Much interest has been centred on obtaining alloy powders, suitable for admixture with stock iron powders for the manufacture of strong low-alloy content compacts or for alloy parts for high-temperature application.

The hydride process has been used for preparing nickel-chromium alloys by reduction of the mixed oxides with calcium hydride. Stainless-steel powder produced by chemical disintegration is described in a paper in Group III by Dr. P. Marshall (Metal and Plastic Compacts, Limited). One of the most important developments since the war has been the production of ferrous alloys by atomisation, in the United States, by the Vanadium-Alloys Steel Company, and in the United Kingdom by Powder Metallurgy, Limited.

Vanadium Alloy Steels Company make several standard grades of stainless-steel powders corresponding to A.I.S.I.302 B, 316, 318 and 431.

TABLE I.—Mechanical Properties of Powder Compacts

Process	Grade	Compacting pressure, lb. per sq. in.	Density after compacting, grammes per c.c.	Properties after sintering for 1 hour			Sintering, temp. deg. C.	No. of and sintering compacting cycles	Apparent density, grammes per c.c.
				Density, grammes per c.c.	Tensile strength, lb. per sq. in.	Elongation, per cent.			
Höganäs ..	M 100	60,000	5·80	5·85 6·55	13,000 23,000	5·5 13·5	1,100 1,100	One Two	—
	M.H.	60,000	6·25	6·20 6·50	16,000 24,000	5·5 14·5	1,100 1,100	One Two	—
	Ancor 80 (Riverton U.S.A.)	60,000 —	6·20 —	6·25 6·20	— 20,000	— 8	— —	One —	—
Easton ..	R.Z. Type	60,000	6·3	—	18,000–19,000	7	1,120	—	2·4
		100,000	—	—	28,000–29,000	7			
Ferrum ..	—	—	No details available				—	—	2·8–3·0
Pyron ..	—	50,000	5·86	—	12,500	5·25	—	—	—
		100,000	—	—	22,500	7·25	—	—	—
National Radiator	Reduced and electrolytic		No details given						
Husqvarna ..	Standard ..	60,000	6·7–6·8	—	18,500	5	1,050	One	—
		85,500 (1) and 60,000 (2)	—	—	35,600	26	1,050 (1) and 1,250 (2)	Two	—
	Sponge ..	60,000	6·4–6·6	—	25,600	13	1,050	—	—
		85,500 (1) and 60,000 (2)	—	—	37,000	21·5	1,050 (1) and 1,250 (2)	—	—

Most of these powders (minus 100 mesh) if pressed at 80,000 lb. per square inch and sintered for 45 min. at 1,230 deg. C. give compacts with tensile strengths of 30,000 to 40,000 lb. per square inch and elongations of 5 to 15 per cent. Repressing at 80,000 lb. per square inch and resintering at 1,230 deg. C. improve the tensile strengths to 55,000 to 65,000 lb. per square inch and the elongation to 12 to 24 per cent. The best physical properties were obtained with a stainless steel, 318 Si (Cr-Ni-Mo-Nb-Si), which showed a tensile strength of 92,000 lb. per square inch and an elongation of 36 per cent. These powders have been used not only for engineering components but also for filters and as a raw material for the manufacture of stainless-steel flake powder.

In "Powders for Magnetic Applications," Mr. G. R. Polgreen (Salford Electrical Instruments) considers that electrolytic, carbonyl and sponge-iron powders provide most of the basic material used for electrical applications. For these, the magnetic requirements may be one of the following: (i) low loss at low flux density, as for telephony and radio cores; (ii) low loss at high flux density, as for pole pieces, transformers and armatures for motors; and (iii) high hysteresis loss, as for permanent magnets of all kinds.

The first group mainly requires low eddy-current loss, which involves the use of finer powders as the operating frequency is increased; the second requires low hysteresis loss and an insulated coarse powder will generally give a core with negligible eddy-current loss at the lower-power frequencies; in the last group, the object is to store the maximum energy in a given volume and a figure of merit of a permanent magnet is the energy factor which is a measure of the hysteresis loss. This is a product of B and H in the second quadrant ($BH_{max.}$) the units being gauss and oersted, respectively.

The coercive force is critically dependent on the particle size of the powder from which the magnets are made. A powder of pure iron with a particle size of 0·01 to 0·02 micron will have a coercive force of 1,000 oersteds and if it is pressed, this value will be halved approximately but the remanence will be increased to about 5,000 gauss. It is shown how it is possible with pure iron, classically a low-loss metal, to make either low-loss cores or permanent magnets depending upon the particle-size grouping.

The general characteristics of electrolytic, carbonyl, sponge powder, oxide-ferrites powders for low-loss applications are discussed. The hydrogen reduction of single or mixed oxides or salts is the only material that can be used to produce on a commercial scale nearly all metallic magnetic powders in any required size grading; a plant is described which has operated 14 years for producing iron and magnetic-alloy powders for manufacture into a great variety of telephone and radio cores. Details of the production of iron or alloy micro powders are also included. The advantages of micropowder magnets, as compared with other types, are: (i) lighter weight; (ii) generally lower cost using iron micropowder; (iii) ability to drill, machine and shape the pressed magnets; (iv) ability to mould intricate shapes to accurate dimensions; (v) economy of strategic and expensive metals such as cobalt; (vi) control of remanence-coercivity over a wide range and accurate control of magnetic properties in production; (vii) great uniformity of density throughout a pressing, which is especially important for parts rotating at high speed and also instrument magnets; and (viii) the low-temperature moulding method permits the incorporation of inserts or the simultaneous pressing of different kinds of powder. Future developments will be the preparation of oriented cores or magnets which will require shaped particles. If elongated particles could be made with a minimum dimension of domain size and a maximum five times as large, and if such powders could be oriented within a magnet by pressing to 50 per cent. theoretical density, theoretical considerations show that pure-iron micropowder magnets could be made with a coercive force of 3,000 to 5,000 oersteds and a remanence of 5,000 to 16,000 gauss. Powder metallurgy thus possesses considerable scope for developing magnetic materials.

NON-FERROUS METAL POWDERS

Though expansion has occurred in the manufacture of reduced and electrolytic copper or atomised alloys, few new technical or scientific developments have been made. It is understood that plants for the manufacture of atomised aluminium have been installed in Britain by the British Aluminium and the Northern Aluminium Companies. The manufacture of atomised brass powder with an irregular particle shape has been useful; this has resulted in better green strength in the compact and has contributed to increased production of brass components.

In recent years, a development of outstanding interest has occurred in hydro-metallurgical extraction of metals, some in the form of powders, from their ores. The most important of these, the Chemico Metals Process, depends upon the general principle of dissolving a concentrate of scrap metal with suitable acids or alkalis, purification of the solution and finally precipitation of the pure powdered metal using either hydrogen or carbon monoxide at elevated temperatures or pressures. Two plants in Canada and one in the United States are in production or being erected: one is designed to produce 2,000 tons of cobalt powder a year; another will produce annually 700 tons of cobalt powder, 900 tons of nickel and 700 tons of copper, as well as 7,500 tons of ammonium sulphate; the third, a nickel refinery, is designed to produce every year 8,500 tons of nickel powder, 1,000 tons of copper, 150 tons of cobalt and 70,000 tons of ammonium sulphate. A number of plants are being erected under licence to the Chemetals Corporation, of New York, for refining copper and brass scrap and refinery

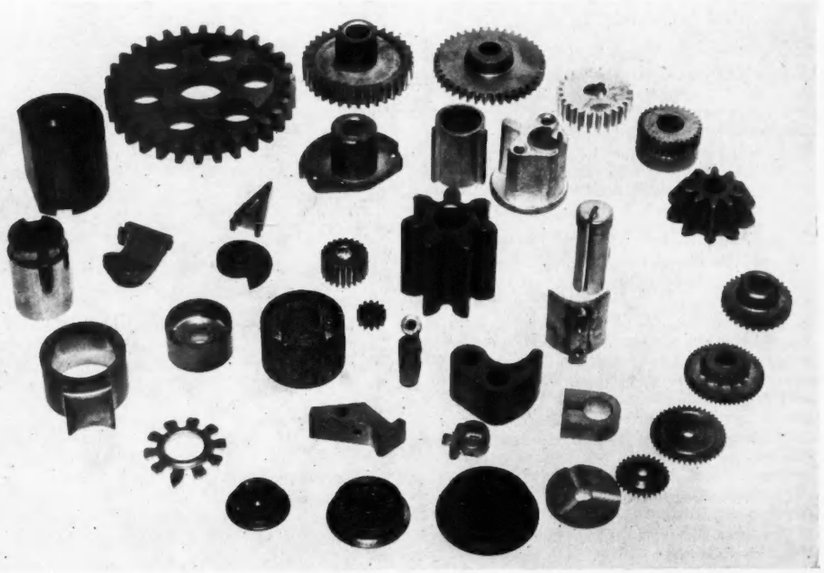

Fig. 1 Examples of the range of engineering products made in the United States during 1953 by the sintering process from metallic powders.

by-products. This Corporation is extensively promoting development of techniques for the direct rolling of powder into sheet and strip and copper-powder extraction plants will probably operate in conjunction with rolling plants manufacturing copper sheet. Dr. Jones concludes that these new activities which he terms "Powder Extraction Metallurgy" and "Continuous Powder Metallurgy" are developing simultaneously.

The fabrication of tantalum is described by Mr. R. Titterington and Mr. A. G. Simpson (Murex, Limited) and users will find useful information in their paper on rolling, swaging, wire-drawing, annealing, deep-drawing, welding, and machining the metal. Tantalum combines readily with oxygen and nitrogen and must be mechanically worked at room temperature. The rate of work-hardening for tantalum is very low and therefore considerable cold work can be undertaken before annealing becomes necessary. The metal can be single-sheet rolled down to 0·010 in. thick, but sheets down to 0·002 in. thick can be produced by pack-rolling two sheets from 0·02 in. Recently, foil production has become necessary and thicknesses down to 0·0001 in. are now obtained in a cluster mill. The economic limit for tantalum foil is 0·0005 in. Tantalum bars are swaged and then drawn to wires with a minimum thickness of 0·004 in. The annealing of tantalum is difficult, since it is so reactive towards residual furnace gases; all material is wrapped in tantalum sheet or placed in a box with a tight-fitting lid. Cold-worked sheet or wire is annealed when hardness values of 170 to 190 (D.P.N.) have been developed.

TESTING OF POWDERS

Developments in testing metal powders, reviewed by Mr. G. R. Bell (Powder Metallurgy, Limited) have been confined to improvements in existing apparatus, though extensive work has been done to assess the magnitude of errors in various tests and correlating results obtained from different methods. American standards are increasing in importance in a widening field. Notable work has been undertaken on the automatic counting and sizing of particles. The review is divided into sections dealing with work on particle shape, particle density, the surface condition of particles, size distribution, sieve testing, counting using a light microscope, sedimentation, centrifugal analysis, elutriation, turbidimetric analyses, permeability measurements, surface absorption, and miscellaneous methods.

An instrument, described in "Application of Particle Size Analysis to the Quality Control of Metal Powders," by Mr. V. T. Morgan (Bound Brook Bearings, Limited), has been found particularly useful in the United Kingdom and America for determining, on a routine basis, the comparative particle-size distribution of metal powders. The instrument based on principles of sedimentation and photo-extinction turbidimetry employs autographic recording and a complete sub-sieve analysis can be made in about 20 minutes.

2.—PRINCIPLES AND CONTROL OF COMPACTING AND SINTERING

In this Group of fourteen papers, an account is given of some properties of filter elements by Mr. V. T. Morgan (Bound Brook Bearings, Limited). The degree of interparticle welding produced during sintering is related to its effect upon mechanical strength, porosity, permeability and pore-size. An improvement in strength is shown graphically to be obtained at the expense of permeability. Consequently, in practice, a compromise between these two opposing factors is essential. It is shown that efficiency of filtration depends on the relationship between the sizes of the sediment particles and those of the pores of the filter. A useful relationship is given for the pore size and permeability of a range of ceramic and metal filters.

A laboratory investigation on the relationships between the properties of iron powders and powder compacts is described by Professor F. V. Lenel (Rensselaer Polytechnic), Mr. H. D. Ambs (Frankford Arsenal) and Mr. E. O. Lomerson (Pratt and Whitney Aircraft Corporation). Although no attempt was made to produce in the laboratory powders which would meet the requirements of commercial powders, some of the conclusions of the investigation should be of assistance, according to the authors, in controlling the methods for producing commercial powders in such a manner that they would yield higher-strength compacts. Increasing the temperature of reduction of oxide for the manufacture of powder and also the severity of comminution both make the powder particles smoother and less irregular. Such changes in surface configuration result in lower tensile strengths of the pressed and sintered compacts. The compressibility of the powders increases with increasing temperatures of reduction and more severe methods of comminution. Micrographs illustrate that comminution of the sponge powder is most severe after wire brushing and becomes less severe progressively in a mortar and pestle, disc milling and hammer-milling respectively.

Considerable interest has been aroused in recent years by development work in Germany on the direct production of metal sheets on a pilot-plant scale from powders. The results of an investigation, the first which seems to have been prepared by an independent authority, and for that alone it is particularly welcome, are reported by Mr. P. E. Evans and Mr. G. C. Smith (Cambridge University). Copper powder was compacted by direct rolling in a standard two-high rolling mill to produce a continuous length of metal strip, and data were sought on the influence of rolling pressure combined with standard sintering conditions with varying time and temperature. The powder, contained in a hopper, was fed to the rolls by means of an inclined shute. The feed rate, controlled by the aperture of the hopper and inclination of the shute, was not critical provided that enough powder was always present at the roll gap to ensure a continuous supply for compaction. The width of strip was limited by the width of the feeding shute, though this could be raised very nearly up to the absolute limit of the barrel length of the roll. The rolling mill consisted of a two-high stand with 8-inch diameter rolls driven at 24 r.p.m. by a 25 h.p.-electric motor. Metal powder is fed into one side of the mill and issues horizontally as compacted strip on the other. The strip thickness can be varied within narrow limits by varying the roll gap from that size at which the strip is just strong enough for subsequent handling to that size obtained when the rolls are initially pressed tightly together. The maximum thickness of strip which can be produced sufficiently strong to be handled appears from previous investigations to increase almost linearly with the roll diameter. Other factors such as roll speed, and powder-particle size will also affect the thickness. Strip with good edges is produced in conjunction with guides used in the roll gap to restrict lateral flow.

Electrolytic copper powder was used throughout the investigation as the most suitable material since the powder, possessing good compacting properties and a wide range of particle shapes and sizes, is readily available. It is clearly shown that the roll gap critically influences the mechanical and physical properties of the strip: the maximum green density, but not that after sintering at 1,000 deg. C. for two hours, occurs at the minimum roll gap; the thickness of both green and sintered strip decrease non-linearly with dimishing roll gap; the maximum strength, about 18 Kg. per square millimetre ultimate tensile strength, and elongation of about 15 per cent. are obtained at low but not the minimum roll gap and correspond to the point of maximum sintered density, namely, 8·1 grammes per cubic centimetre.

After the effect of different rolling conditions had been established, strip was rolled to a uniform green thickness of 0·60 mm. and sintered under various conditions. The ultimate tensile strength, percentage elongation and density of green strip increase markedly in the first 60 minutes of sintering at 1,000 deg. C., after which a gradual increase occurs up to the maximum time. The same properties show a slow increase with two hours of sintering up to 750 deg. C. and a more rapid increase up to about 1,000 deg. C. The maximum values obtained in these two series were ultimate tensile strength, 9·5 Kg. per square millimetre, elongation, 8 per cent., and density, 7·0 grammes per cubic centimetre. Strip which had been rolled to a green thickness of 0·60 mm. and sintered for 130 minutes at 1,000 deg. C. was cold rolled to thickness reductions ranging from 8 per cent. to 67 per cent., and annealed for 1 hour *in vacuo* to promote recovery. Transverse cracks appeared at the edges with deformations greater than 50 per cent. Cold-rolling produces a marked improvement in properties, the following maximum values being obtained at 47 per cent. to 50 per cent. deformation: ultimate tensile strength, 27 Kg per square millimetre, elongation, 33 per cent., and density 8·78 grammes per cubic centimetre. No attempt is made to consider the economic aspects of this process, but the commercial possibilities have already been referred to in the paper by Dr. W. D. Jones.

Sintering-furnace atmospheres for industrial practice are reviewed by Mr. L. D. Brownlee, Mr. R. Edwards and Mr. T. Raine. The considerations involved in choosing a suitable atmosphere include the effect of the atmosphere on the metal, on the oxide of the metal, on compounds such as carbides of the metal and on furnace refractories.

3.—MANUFACTURE AND PROPERTIES OF STRUCTURAL ENGINEERING COMPONENTS

The scale of American and European production of some engineering parts is assessed in a comprehensive paper by Mr. C. J. Leadbeater (Armament Research Establishment). Production data are quoted for America, Italy, France, Germany and Great Britain, and it is significant that developments have occurred in variety and scale of production in numerous countries. In the United States the use of iron powder in bearings and parts in 1953 was 7,500 tons as compared with 3,000 tons in 1948. Copper-powder production for self-lubricating bearings, mechanical parts and friction materials amounted to nearly 12,000 tons in 1953, almost double that used five years previously. The total consumption in Italy is estimated to be 700 tons per annum for iron, steel and copper infiltrated parts which are used for automobile shock-absorbers, cages for ball bearings, suspension bearings, parts for meters, motor cycles and textile machinery. In France, the second year of production was 1953, when nearly 600 tons of iron and copper powders were used. The 1954 production of parts in Germany is estimated to be 1,100 tons as compared with 300 tons in 1949. A two-fold increase in parts production has recently occurred in the United Kingdom, 550 tons of iron and 900 tons of non-ferrous powders (mainly copper, brass, bronze) being used in 1954.

The scope of application of sintered parts in the United Kingdom may be judged from the following. In one plant, 300 parts mainly iron base were currently in production and were being used in the following proportions: 21 per cent. for motor-cycle parts (fork bushes, thrust and chain-wheel washers, gear-box brushes); 11 per cent. for motor-car parts (bushes, thrust washers, door-lock parts); 3 per cent. for cycle components (handlebar and brake-lever washers, hub gears); 18 per cent. for gun components (magazine catches, triggers, sight-locking bolts); 5 per cent. for electric motors (pole pieces); 12 per cent. for miscellaneous textile components; 30 per cent. for miscellaneous engineering parts.

The variety of shape and size of current sintered engineering components are illustrated in Fig. 1 Technical developments in materials have been gradual and existing data confirm

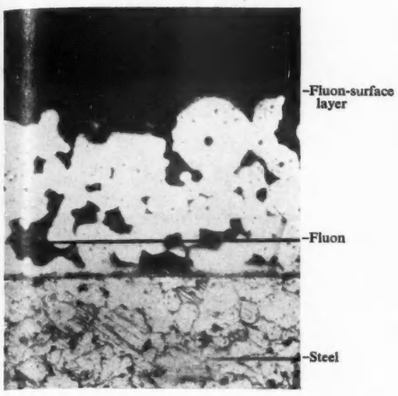

Fig. 2 Steel-backed porous bronze bearing impregnated with Fluon.

that ferrous parts form 60 per cent. of the total production. The strength of ferrous parts has been improved by the use of several methods. (1) The powder mixes consist of iron with copper, nickel or carbon. Copper is now universally used for improving the strength of parts and, in the United States, the usual content ranges from 2 per cent. to 7·5 per cent. Data are collated for fine iron powders mixed with up to 10 per cent. copper and processed differently resulting in ultimate tensile strengths, depending also on the density of the compact, from 8·6 tons per square inch (low density) to 38 tons per square inch (high density). The addition of nickel up to 20 per cent. in an iron-powder mix results in an increased tensile strength of up to 45 tons per square inch in the sintered compact. The inclusion of carbon in the iron-nickel mix produces significant changes in properties in alloys of intermediate nickel contents; as the carbon content was increased up to 1 per cent., a lower nickel content was required to produce the maximum strength in a given series of alloys. The manufacture of components such as rifle magazines, catches, triggers and cycle-hub gears, from iron containing 5 per cent. nickel has increased in the United Kingdom and the average properties, depending on nickel content and processing, are:—ultimate strength, 26–32 tons per square inch; Brinell hardness 120–180; elongation, 6–12 per cent.; and density 7·0 grammes per cc. Cyanide hardening or chromium plating can be applied to such components to develop wear-resistant surfaces.

A porous matrix such as iron may be infiltrated with molten copper or bronze in order to improve its strength or wear resistance, especially when the infiltration process is followed by carburizing. (By infiltration is meant the preliminary production of a porous skeleton by sintering a high-melting metal and afterwards filling the pores of the skeleton with a low-melting metal, the latter being termed the infiltrant metal). Dense or nearly fully-dense material is obtained in this way and the mechanical strength is substantially improved by the elimination of the notch effect existing in the periphery of individual pores. Iron matrices with porosities ranging from 25 per cent. to 10 per cent. were infiltrated to various degrees up to 100 per cent. theoretical density and developed tensile strengths ranging from 14·2 tons per square inch to 45·4 tons per square inch. A considerable amount of copper infiltration is carried out in the United States using a bronze containing iron which is deliberately added to minimise the dissolution of iron at the surface during infiltration. A recent addition to large-scale techniques in the United States has been the use of brass instead of bronze for infiltration since the process occurs more easily and lower working temperatures are required. Leaded copper-zinc brasses (90/10; 80/20; 85/15) were used. The disadvantages of brass infiltration include the loss of zinc with consequent frequent shut-downs to clean out the furnace or replace the heating elements which have deteriorated.

As a postscript to the manufacture of high-strength parts, Dr. L. Harrison (Sheepbridge Engineering Limited), and Mr. S. Marton (Sintered Products, Limited) describe some experiments on the production of high-strength material and parts by powder metallurgy using the techniques of (1) single sintering and pressing, (2) double pressing and sintering, (3) infiltration of a porous iron skeleton. Generally, for small components with a very high cross-section to thickness ratio and relatively simple shape without varying levels in the direction of pressing, method 2 is ideal for achieving high densities and maximum strength by means of carburization which is effective throughout the thin section; this method is equally important for parts which require ductility and dimensions to close tolerances. Method 1 is the most suitable for parts of intricate shape needing complicated tools, and the dimensions of parts can meet most commercial limits. Where a wide tolerance in dimensions is permitted, infiltration becomes the first choice, since if the need for sizing is eliminated this method is the cheapest of the three. If large parts are required, infiltration is again a good choice, from the standpoint of economy and ease of production.

NON-FERROUS METALS

Sintered-brass parts are growing in importance since the main difficulties such as loss of zinc from the component during sintering, lack of ductility, contamination of the furnace necessitating frequent shut-down for cleaning operations are being brought under control. Recent practice has tended to use brass powder containing intermediate zinc contents to minimise loss. The most widely-used grade contains 78·5 per cent. copper, 20 per cent. zinc, 1·5 per cent. lead and its general acceptance is strongly linked to the improved machinability of the part resulting from the presence of lead—an important advantage for secondary operations such as under-cutting, drilling and threading, all of which can be achieved with normal cutting tools. Data from three sources on the mechanical properties of sintered-brass parts show variations in tensile strength from 15,100 lb. per square inch to 35,000 lb. per square inch and elongation from 3·5 per cent. to 48 per cent. The inclusion of 0·3 per cent. phosphorus in the brass results in a striking improvement in elongation. Applications for sintered-brass parts include matching governor weights and drive bar, dishwasher timers, pin-tumbler padlocks, lock cylinders for eight different companies, faucet handles, booster rotor fuse components, firing plugs for U.S. Army M 32 percussion primers and compass bezel rings.

FRICTION MATERIALS

Increased production facilities have become available in the United Kingdom during 1954 for making single discs up to 18·5 in. external diameter and segmental discs up to 24 in. diameter from facings of bronze containing silica, graphite, and lead, diffused to a rigid iron backing plate. These components are used as clutch or brake linings in earth-moving equipment. Four commonly used grades are characterised by low friction (up to 0·15) for wet and dry applications, uniform and fairly low friction (0·2) and high friction (0·4 to 0·5). Sintered friction plates are justified on performance rather than cost and are generally manufactured in simple ring, ring-segment or rectangular shapes.

The work of Mr. E. V. Walker, Mr. R. E. S. Walters (Post Office Engineering Research Station) and Mr. D. K. Worn (Mond Nickel Company) has demonstrated the potentiality of powder metallurgy in the production of high-permeability magnetic alloy strip of Permalloy C or Mumetal (normally 77 per cent. Ni, 14 per cent. Fe, 4 per cent. Mo and 5 per cent. Cu). The material made by compacting and sintering was found to be superior and more consistent in properties than those of the conventionally produced alloys, and these differences are attributable to the higher purity and closer control of composition achieved in the alloys produced from powders. The maximum magnetic permeability of the cast and rolled alloys (mean 28,000) are obtained after annealing the stock in very pure hydrogen, which is a difficult operation commercially. The powder-metallurgy product can be annealed, however, in wet hydrogen without detriment to give a mean permeability of 30,000. Trials are now in progress under conditions appropriate to commercial production and it is expected that quantity production of high quality strip will be successfully developed.

One of the outstanding exhibits at the Symposium was a group of Fluon (polytetrafluorethylene) impregnated materials. Some important work has been done in the United Kingdom in establishing sintered materials the chief attraction of which is low friction. Sintered copper, for instance, impregnated with solid Fluon, has a coefficient of friction of 0·05 between 15 and 250 deg. C., above which the plastic begins to decompose. The friction coefficient of sintered copper in the same temperature range increases from 0·24 to 0·8, while that of machined copper decreases from 1·3 to about 1·0. Various types of bearings have been designed to take advantage of the promising features of Fluon. Fluon is incorporated in steel-backed sintered lead-bronze bearings by impressing powder or sheet into the bearing surface and heating at 350 to 400 deg. C. at a pressure of 1 ton per square inch until the softened plastic fills the pores to a depth of at least 0·03 in. This is shown in Fig. 2. Fluon-impregnated bushes and thrust bearings, the manufacture of which began about two years ago, possess excellent properties as a dry bearing surface, and field tests have shown them to be widely applicable where lubrication is impossible or undesirable, as in textile and food machinery. Since a lubricant, however, is not used, the speed-load factor for such a material is considerably lower than that of a lubricated bearing. This point should not be over emphasised since the conditions of operation of many types of bearings are not severe and Fluon-impregnated bearings should find wide applications.

Methods of preparing and testing fluon-impregnated self-lubricating bearings are described by Dr. A. Blainey (Atomic Energy Research Establishment, Harwell). It was found that these materials would operate dry in corrosive nitric acid solutions or in gasoline, high surface speeds being permissible when a liquid cooling medium was present at the bearing surface.

4.—POWDER METALLURGY OF HIGH-MELTING-POINT MATERIALS

Group IV of the Symposium contains 12 papers on high-melting-point materials, 10 of which describe materials for use at high temperatures. Mr. E. C. Green, Mr. D. J. Jones and Mr. W. R. Pitkin (General Electric Company, Limited) describe developments in heavy alloys of tungsten-nickel-iron. These materials find extensive application for protection against radio activity, for heavy-duty electrical contacts and for mass balancing. Since tungsten is soluble in iron as well as in nickel, the authors devised compacting and sintering procedures for three tungsten (90 to 95 per cent.), nickel (7 to 3·5 per cent.) and iron (3 to 1·5 per cent.) alloys. The results indicated that (i) the density achieved was independent of time and temperature, (ii) in general, tensile strength and elongation increase with sintering time and temperature, (iii) the elongation is greater for the slowly-cooled specimens, and (iv) the elongation decreases with increasing tungsten content. The outstanding quality about some of these alloys is their high elongation which enabled substantial cold rolling to be undertaken. Sintered sheets, measuring 6 in. by 1·5 in. by 0·125 in., could be cold deformed by cross rolling in steps of 60 per cent. reduction of cross-sectional area to sheets 18–24 in. long by 2–2·5 in. wide, or 6 in. long by 4–6 in. wide. Intermediate anneals at

1,450 deg. C. were necessary after each 60 per cent. reduction in cross-sectional area produced in cold rolling. Such improvements in elongation must undoubtedly increase the range of application of heavy alloys in the engineering field.

Variation in carbon content in standard sintered tungsten-carbide-cobalt is shown by Mr. L. W. Brownlee, Dr. R. Edwards and Dr. T. Raine to produce a marked reduction in the transverse rupture strength. A 0·2 per cent. of surplus free carbon will reduce the rupture strength from 90 to 65 tons per square inch and similarly a deficiency of 0·1 per cent. carbon will reduce the rupture strength from 90 to 55 tons per square inch. Very rigorous control of the carbon content during manufacture of "hard-metal" tool tips is imperative, since carbon deficiency, although characterised by high wear-resistance, tends to result in cracking and breaking of the tip. In addition, such a hard metal is very liable to develop cracking on brazing and crumbling of the cutting edge during grinding. Mr. Brownlee and Drs. Edwards and Raine are on the staff of the Metropolitan-Vickers Electrical Company.

The remaining papers in this group are devoted to materials for high-temperature application and though many data are included, it is unlikely that these materials will find application until their toughness has been improved.

* * *

THE MICHELL BEARING

Practical Experience and a Theoretical Investigation

Considering that nearly half a century has elapsed since Mr. A. G. M. Michell took out the original British Patent for the thrust bearing which bears his name, it is a remarkable tribute to the soundness of his conception, and to the practical engineering sense of those who applied it, mainly to marine propelling machinery and power-station turbines, that it has been the subject of so little laboratory investigation. It was inevitable, however, that the development of the refined laboratory techniques and apparatus that are now at the disposal of research workers should inspire the wish to examine, by these more precise methods, the functioning of a device that has so greatly influenced the evolution of rotary prime movers of large powers.

This research has been undertaken in the engineering department of the University of Sheffield and the results are contained in a paper entitled "Michell Bearing Lubrication," recently circulated by the Institution of Mechanical Engineers for written discussion (which, it may be noted, should be in the hands of the Secretary of the Institution by January 3, 1955). The investigation dealt with thrust bearings only, and covered oil-film pressure distribution, what the authors conveniently term "film geometry," friction characteristics, and temperature distributions for a considerable range of speeds, loads, oil viscosities and pivot positions. The first part of the paper, by Dr. C. F. Kettleborough, A.M.I.Mech.E., Mr. B. R. Dudley, B.Sc.(Eng.) and Mr. E. Baildon, M.Sc.(Eng.), A.M.I.Mech.E., records the experimental results obtained, and in the second part, Dr. Kettleborough, who is now a senior lecturer in the University of Melbourne, compares the experimental results with the existing theory.

The results obtained, in the authors' words, "confirm that fluid film lubrication exists for pivot positions not only in the conventional position, but also for central pivoting and pivoting on the inlet side of the pad"—in other words, that the bearing will still function if run in the reverse direction of rotation, which has long been known. The results also provide interesting quantitative data. In brief, they amount to the assurance, which really is hardly necessary, that the design principles evolved by the practical engineers who developed the application of the Michell thrust are, after all, correct.

Autumn Meeting of the Iron and Steel Institutute (*concluded from page* 819)

FATIGUE TESTS ON ROLLED ALLOY STEELS

At the last technical session of the recent two-day autumn general meeting of the Iron and Steel Institute, held on the afternoon of Thursday, November 18, the newly-issued special report, No. 50, of the Institute, by Mr. P. H. Frith of the Bristol Aeroplane Company, Limited, Filton, Bristol, was presented and discussed. The subject of the report was "Fatigue Tests on Rolled Alloy Steels made in Electric and Open-Hearth Furnaces."

Mr. Frith, who presented the report, said that the first part of it was concerned with steels heat-treated from 60 to 100 tons per square inch ultimate tensile strength. The steels used for these tests had been manufactured by an approved method, and examination by the current-flow and magnetic-flow tests, after finish machining, had revealed a high degree of "cleanness." The values for the fatigue ratio obtained with reversed bending and reversed torsional stresses in the longitudinal and transverse directions were similar for both basic electric-arc normal-procedure and acid open-hearth steels, heat-treated to 60 tons per square inch ultimate tensile strength. Increasing the ultimate tensile strength to 80 tons per square inch did not affect the fatigue ratio for reversed bending tests, in the longitudinal direction, of neutral or basic open-hearth steels, but in the transverse direction the ratio was reduced. A further reduction in the transverse reversed bending fatigue ratio was obtained for basic electric-arc normal-procedure, acid open, hearth and basic open-hearth steels by increasing the ultimate tensile strength to 110 tons per square inch, the longitudinal reversed bending ratio being also reduced.

Inclusions, of the size and type present in the steels examined, did not appear to be detrimental to the reversed bending and reversed torsional longitudinal or transverse fatigue properties of the steels, heat-treated to 60 tons per square inch ultimate tensile strength. On the other hand, inclusions of the undeformed spheroidal silicate type reduced the longitudinal fatigue limit of the basic electric-arc normal-procedure steel heat-treated to 110 tons per square inch ultimate tensile strength by at least 17 per cent.

The second part of the report dealt with steels heat treated to a hardness of 750 diamond-pyramid numbers. The steels used for these further tests were of the carbon-chromium type and they were also manufactured by an approved method. The current-flow and magnetic-flow tests again revealed a high degree of cleanness.

The longitudinal reversed bending fatigue limit of a British basic electric-arc normal-procedure steel was 26 per cent. lower than that for a British "neutral" open-hearth steel, while two Swedish acid open-hearth steels tested had fatigue properties slightly inferior to those of the British neutral steel. The low fatigue properties obtained on British basic electric-arc normal-procedure steels appeared to be due to the presence of undeformed spherical silicate inclusions. By modifying the melting technique these undesirable inclusions could be eliminated, and the fatigue properties were then similar to those obtained for open-hearth steel.

The "neutral" open-hearth steel had been made in a furnace having a basic hearth, using an acid charge—no heavy lime slag was require to remove phosphorus. This type of steel had been previously referred to as "basic hematite," "neutral," "special basic" and "S.P.B." (Sheffield Process basic).

DISCUSSION

Dr. H. H. Burton, in opening the discussion, said that the author's title was extremely modest, because he had referred only to fatigue tests on electric and open-hearth steels, but in fact he had covered very much more ground than that and had gone a long way towards explaining, so far as present knowledge went, the reasons why these types of steel differed in respect of their fatigue properties.

One or two very important considerations, however, should be borne in mind when reading and drawing conclusions from the author's work. First of all, he hoped that it would not lead to a panic effort on the part of steel users to switch over from a process which already gave them perfectly satisfactory results to something else which they might think contained less spherical inclusions of the non-deformable type. The author had done his best to safeguard against this possibility.

Secondly, there was a considerable lesson here in the sense of raising grave doubts concerning the present trend, which he believed was particularly pronounced in the United States, namely, to go in for what were called ultra-high tensile strength steels. It seemed to stand out from the paper that steels, other than ball-race steels, which were used widely in aircraft and other highly-stressed mechanisms, were such that there was very little to be gained in fatigue by going up to very-high tensile strengths. What was the use of increasing the proof stress up to some very high figure if there were not an improvement in the fatigue properties?

BALL-RACE STEELS

With regard to the ball-race steels, which the author had analysed very well indeed and which certainly bore out strikingly the conclusions which he had drawn, he suggested that it was a pity that more British acid open-hearth steels had not been tested. The author's figures had been unduly weighted by one cast which had given rather poor results. It was also unfortunate that there were so few results for acid electric steels, but one of the reasons for that was that there were so very few acid electric furnaces operating in this country.

It was to be hoped that another result of this paper would be completely to "debunk" the ideas held by some people concerning the "terrible effect" of any type of non-metallic inclusion whatever. In specifications it had been common to state that the steel "shall be free from harmful inclusions." No one had defined what a "harmful inclusion" was, but from that had grown a general view that all inclusions must be harmful, and a great deal of very good steel had been unnecessarily rejected.

Mr. R. Wilcock confined his remarks to the steels tested at 750 DPN, namely, the ball-bearing steels. He said that, in the report, mention was made of "scatter" particularly in the lower tensile tests, but relatively little was said regarding scatter in the case of the ball-bearing steels. His colleagues and himself had found that scatter was at least as great in these steels and it was not going too far to say that if only a single test were done the results might be misleading. They had also conducted a large number of tests on various parts of a cast and here again had found a good deal of scatter and no consistency; sometimes the first ingot in a cast gave the best results, while, in another cast, the best results were obtained at a later stage, and, in other casts, the last ingot gave the best results. Furthermore, in the case of nine casts, they had forged test pieces in some cases and rolled them in others, all from the billet, and, again, they had obtained a good deal of scatter, sometimes the forged being better and sometimes the rolled, so that they found it difficult, with

the steels tested well above the fatigue limit, to draw any valid conclusions.

Dr. H. Sutton said that conditions in the aircraft world could be very difficult, and there had been times in the history of some of our aircraft engines when the performance of the bearings was a very critical matter indeed. From personal association with some of these problems, he knew that the present investigation had been of material assistance in that connection.

HIGH-STRENGTH STEELS

Dr. Burton had referred, very appropriately, to a surge of interest at the present time and to a great deal of discussion now going on in connection with the use, or potential use, of very high strength steels. The author and his colleagues had given users some very interesting pointers there. The question of directional properties in the very highest strength steels, which might possibly be used for highly-stressed parts of aircraft and other equipment, and also in industry, was of special interest to engineers.

There were many applications in which, during the whole life of a particular component, it was not necessary to go to very high endurances, but it was a good thing to pay attention to performance at higher stress. There were, on the other hand, very many more exacting conditions of use in which the stress cycles numbered a great many million, and perhaps those were really the more important; but there was a natural tendency to emphasise unduly the behaviour at very high endurances, and sometimes to forget the behaviour at the shorter endurances.

Mr. W. E. Bardgett said that the author had shown that in a 60-ton tensile steel the effect of inclusions in general was very small, but when 80-ton and, particularly, 100-ton tensile steels were considered, the effect of inclusions could be quite deleterious. In the higher tensile steels the deleterious effect of inclusions became manifest from the white area which was formed, the centre of which was an inclusion. It was a little difficult to visualise why it was that the inclusion should be so detrimental below the surface when, apparently, a similar type of inclusion on the surface was very much less detrimental. The conclusions on this put forward by the author were probably correct.

The author had assessed his ball-race steels on the basis of a rotating cantilever specimen with one-point loading, giving uniform bending over a certain length. This immediately raised the question of the extent to which a test of this type did actually assess materials which were going to be used in the form of a ball-race. It had been stated that the correlation was quite good, and the author had suggested that, at any rate, it was a very good sorting test. Obviously, something more than that would be desirable if it could be obtained. What was wanted was a quick test to assess material in the form of a ball-race.

With the object of providing a truly simulated type of test and giving a reliable assessment of steels, through co-operation and discussion with a number of firms, including the Skefko Company, the Hoffmann Manufacturing Company and Messrs. Samuel Fox, a machine had been developed which was designed by the Hoffmann Manufacturing Company, and this machine showed some promise.

Professor G. Wesley Austin stated that the author had shown, as Dr. Burton had pointed out, that, with increasing strength and hardness, the fatigue strength hardly came up to expectations. That was a very general point. In the rotating bending machine used by the author the surface played a very important part, as it did, indeed, in the application of many of these materials, but from the fundamental standpoint the use of a push-pull machine might help him in any further work which he contemplated.

Dr. M. L. Becker said that the present work had been going on for 13 years. One of the features which had emerged at quite an early stage was the need for further testing facilities. The Fatigue and Inclusions Committee had fully supported B.I.S.R.A. in this matter and, in fact, had strongly recommended that B.I.S.R.A. should put down a number of fatigue-testing machines to carry on this type of work. This has been going on now for a year or two, and results were beginning to come out, so that, before long, it would be possible to place before the Institute further work following up, or proceeding on lines parallel to, that which was being conducted by the Bristol Aeroplane Company.

Dr. N. P. Allen referred again to the general point that as the strength of a steel was increased the gain in fatigue limit was not as great as could be desired. Dr. Burton had rightly used that observation as a warning against the unconsidered use of very high tensile steels, following a fashion which appeared to be growing in favour at present. He wondered, however, whether users ought to be too easily warned off these high-tensile steels.

What impressed him most strongly was that if, at the beginning of the work, it had been said "What was the maximum fatigue strength that could reasonably be expected to be obtained in a steel?" probably the author would have replied that it was something like 30 tons per square inch, or some comparatively modest figure of that kind; but, for reasons which were not at all clear, it had nevertheless been possible to increase the fatigue strength of these strong steels by quite a considerable proportion, and fatigue limits of 50 tons per square inch were now available. That had been done by a modification of steelmaking procedure, and was a notable advance.

The question arose of whether the limit had now been reached or whether it was possible that, if the study of the matter continued, in due course, steels with a fatigue limit of 70 tons per square inch would become available. Metallurgists ought not to be too easily persuaded that the limit of progress had been reached.

Mr. E. Ineson spoke regarding the reproducibility of fatigue-test results. He said that the author had referred to the pronounced scatter of results and had offered several metallurgical reasons for this, but it was clear that the scatter of fatigue results was inevitable, as speakers had pointed out in the case of their own results. It seemed that this scatter must arise first of all from material variations and secondly from testing procedure, and the first of these could not be investigated without a full knowledge of the second. In the B.I.S.R.A. laboratory they had carried out experiments to gain confidence in their testing procedure, and they had found this variability and had compared the variability between machines and also between laboratories.

INCONSISTENT RESULTS

The main conclusions of this work showed that, with very careful attention to the methods of testing and specimen preparation, reproducible results could not be obtained for a particular machine and, when other machines were introduced into the experiment, significant differences began to appear. When a comparison was made between laboratories, even more significant differences appeared. This led him to wonder whether the author's proposal of a fatigue specification for steels could ever gain general acceptance. It would be very difficult for persons to agree on results obtained in different laboratories.

Another point concerned inclusion counting. The author had referred to metallographic counting and to the differences which were obtained and the difficulties of getting agreement between different counts. It could not be gathered from the paper how many samples had been observed and how representative of the material these micro-radiographs were.

Dr. H. H. Burton, who spoke again, confessed to a feeling of disappointment that so many speakers had concentrated almost entirely on the ball-race steels. The main work which had been done, in line with the work of the Inclusions Sub-Committee, was on steels of 60–110 tons tensile strength. He would like to suggest, therefore, that in the further discussion in writing, in which many persons would no doubt wish to take part, more attention should be paid to the 60–100 ton tensile steels, and less to the ball-race steels.

Mr. J. Watkinson again referred to the fact that with increased hardness in higher-tensile steels the fatigue strength did not increase, and suggested that this was possibly due to the non-relief of quenching stresses. He stated that in work on torsional fatigue it had been known that if the endurance limit were determined at different hardnesses, as the hardness increased up to a certain point the endurance limit increased. Subsequently, the fact that the tempering temperature had been so low that the quenching stresses were not adequately relieved, had a very adverse effect on the fatigue properties.

Secondly, with regard to the position of fracture, it was reported that there was a marked tendency for the position of fracture in higher-tensile steels to occur below the surface. He found it very difficult to understand why the effect of an inclusion on the free surface of the specimen, where the stresses were greatest, should be less than that of inclusions below the surface. He wondered whether considerable compressive stresses might have been introduced in the higher-tensile steels by the polishing operation, which would remove the point of maximum stress from the surface to some position below the surface. His final point was that any conclusions based on differences in the fatigue life of specimens tested at two or three particular stress ranges must necessarily be tentative.

AUTHOR'S REPLY

Mr. P. H. Frith, in reply, said that when it had first been decided to have a fatigue test in a specification at Bristol for ball-race steels—and it had been in being for a number of years—acceptance tests had been carried out on all casts, and the ball-race manufacturer had done the same. There had been a very large measure of agreement between the two laboratories. Some of the scatter was sometimes due to testing technique, and there probably would be more with the four-point loading specimen than with two-point loading.

In reply to Professor G. Wesley Austin, they did not do a great deal of push-pull testing; from their point of view reverse bending was more applicable to the aero engine. Professor Austin had said that in reverse bending the surface played an important part. With the high-tensile steels they very rarely got fracture at the surface.

Dr. Allen had referred to the fatigue limit not increasing in the same proportion as the ultimate tensile strain above 80 tons per square inch; their opinion was that this was due mainly to locked-up stresses produced in the material, which had to be there to get the hardness and which produced plastic deformation in minute areas which would initiate fatigue. If fatigue limits higher than ± 40 tons per square inch were required—say ± 45 or ± 50 tons per square inch—and it was not desired to have high hardness throughout the material—the best plan was to nitride the steel. The highest fatigue limits were generally obtained by nitriding.

In answer to Mr. Ineson, they had been more concerned, in this work, with getting a general picture of the fatigue properties of various types of steel than with exploring scatter or looking for small differences, which they regarded as more the business of B.I.S.R.A. than of Bristol. They had looked for large differences in the fatigue properties, of 5 per cent. or more.

Mr. Watkinson had referred to quenching stresses. They definitely did produce locked-up stresses in the specimen, and there was no doubt that they were one of the causes of the lower fatigue properties.

Mr. Frith finally showed 15 slides, obtained since the report had been prepared, illustrating inclusions of different types, the last illustration being of the surface cavity after the extraction of an inclusion, of a perfect diamond shape. The diamond-shaped cavity formed by a spherical inclusion, he said, they considered to be detrimental to the fatigue results.

ATTENUATION OF VIBRATIONS BY LEAF SPRINGS

REDUCING INTER-LEAF FRICTION

By A. J. King, D.SC., M.I.E.E., F.INST.P.*

The resilient mounting on leaf springs of a tall fragile structure near a steam hammer is described, and the poor attenuation of vibration obtained was traced to a natural frequency of 6 cycles per second instead of 1·1. The ratio of 30 times between the dynamic and static stiffnesses of the springs was due to "stiction" of the leaves and was completely removed by inserting strips of thin sheet rubber between the leaves at their tips.

When resilient vibration-attenuating supports are required to be effective at low frequencies, less than 30 cycles per second (c/s), it is common practice to use leaf springs in quarter, semi or full elliptic forms. This is because the attainment of the requisite low natural frequency, even with perfectly elastic materials, would involve linear compressions of greater than 1 in., which are difficult to provide by either direct compression or shear loading of resilient materials. It is still more difficult with materials having a high ratio of dynamic-to-static stiffness since the compression required is correspondingly increased. By using leaf springs, it is generally practicable to arrange for compressions of as much as 10 in., or even more. However, experience with such springs has shown that the natural frequency f_0 c/s associated with a compression of h in. may be several times greater than the value deduced from the simple formula† $f_0 = \sqrt{\frac{10}{h}}$ c/s. The reason for this discrepancy became apparent when it was necessary to inquire into the reason for the obvious failure of a certain resilient mounting using leaf springs to attenuate a particular vibration. The mounting had been designed to protect a tall impulse generator, containing many porcelain insulators, from ground shocks caused by the operation of large steam and drop hammers some 50 ft. away. It was estimated that a mounting with a vertical natural frequency of the order of 1 c/s would attenuate the components of the shocks with frequencies greater than 3 c/s sufficiently to protect the insulators from being shattered. The simple formula quoted above indicated that a linear compression of the order of 10 in. would be required. In addition, the height of the stack of insulators, about 20 ft., made it necessary to broaden the base and lower the centre of gravity of the assembly by mounting the stack on a block of concrete weighing 25 tons.

The block was installed in a pit so that the top was level with the ground and the bottom had a clearance of approximately ½ in. from the floor of the pit, the weight being taken by four pairs of semi-elliptic leaf springs, one pair across each top corner. When the springs were screwed down to lift the block they compressed approximately 8 in., so it was expected that the vertical natural frequency would be approximately 1·1 c/s. It was, therefore, disappointing to find, when the block was tested before erecting the insulators, that the vibration of the block caused by the hammer appeared to be greater than that of the surrounding ground. When the block was given a vertical blow by dropping a weight on it, the natural frequency was obviously greater than 1·1 c/s and a vibrograph record showed that it was approximately 6 c/s. It followed, therefore, that the stiffness of the springs to small amplitudes of vibration was some 30 times the static value determined by the load compression. Such a ratio is not unknown among certain so-called "resilient materials" but is not usually associated with high quality steel springs. Upon further consideration it became apparent that while, for large displacements, the leaves of the springs slide over one another, for the small movements encountered in vibrations. the pressure and friction between leaves is sufficient to prevent sliding, and each spring behaves more as if it were solid rather than laminated. It was known that in the past, many suggestions have been made for inserts, such as sheets of zinc and gauze loaded with graphite,* to be put between the leaves of a spring to reduce friction and squeaking, but it was not felt that such measures, which all involve sliding friction, would free the leaves sufficiently to prevent any sign of "stiction."

It was therefore proposed to try inserting pieces of thin sheet rubber between the leaves near the tips. The sheet rubber, in this case neoprene approximately $\frac{1}{16}$ in. thick, was cut into strips the same width as the leaves, and pieces about 2 in. long were coated with powdered graphite and inserted 1 in. under the tips by prising the leaves apart. Larger pieces of the same thickness were also placed under the spring ends. To avoid overstressing the leaves, this operation was carried out with the load removed by lowering the block, and it was feared that some tearing of the rubber might take place during the comparatively large relative movements of the leaves during reloading. However, there was no sign of any tearing although the rubber spread laterally, and a new measurement of natural frequency gave f_0 = 1·1 c/s. When tested with the hammers operating, the vibration on the block was barely perceptible, so the impulse generator was erected and it has not been affected by the vibration. The rubber has been protected from sunlight and is expected to last many years. It is probable that if the springs of motor cars and railway coaches were treated in this way, their riding qualities would be improved and the continuous vibration in railway coaches would be considerably reduced.

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† ENGINEERING, vol. 146, pages 124 and 198, (1938).

* British Patent No. 592,550.

SHORT-CIRCUIT FORCES ON ALTERNATOR END-WINDINGS

The primary object of a paper entitled "Short-Circuit Forces on Turbo-Alternator End-Windings," which was read before the Supply Section of the Institution of Electrical Engineers by Mr. J. B. Young and Mr. D. H. Tompsett on Wednesday, December 15, was to promote discussion of the view that while some short-circuit tests were probably desirable as a check on alternator reactances and on general manufacturing standards it was unnecessarily severe to apply them from the full rated voltage.

In a turbo-alternator with a subtransient reactance of 10 per cent. the initial current following a three-phase short-circuit from no-load rated voltage was ten times the full-load current. If asymmetry occurred in one phase, and decrement was neglected, a peak current would flow with a magnitude 20 times the value of the full-load current. The peak forces associated with the conductors of that phase would therefore reach values of 400 times normal; and although the full-load forces on conductors embedded in the stator slots were not large, in the end-winding structure, which was in air, adequate bracing and packing must be provided without unduly impairing the ventilation. Modern alternators with high ratings required large diameter stator bores and long overhangs, factors which must also be considered in designing the bracing to resist the short-circuit forces.

ASSESSMENT OF DAMAGE

Analysis showed that the magnetic fields throughout the end-winding during short-circuit had a somewhat complex distribution and that, even if the consequent forces were computed, the resulting movement of the coils and the probable damage to the insulation would be almost impossible to evaluate. In fact, the assessment of damage as the result of a short-circuit was very difficult. It was desirable, however, that any design should be proved to have sufficient mechanical strength to withstand whatever conditions might reasonably be expected to be encountered in service.

To correlate analytical work with practical experience a series of short-circuit tests was made on a 60-MW three-phase 13·8-kV 60-cycle alternator. After preliminary short-circuits at 50 per cent. and 75 per cent. of the normal voltage, the windings failed to withstand the final high-voltage insulation test of 28·6 kV for one minute, although a test voltage of 30·6 kV between phases and to earth had been sustained for the same period. Examination showed that out of a total of 120 half coils 19 had failed to withstand voltages to which they had previously been successfully subjected. Failure in 16 of these cases had occurred just beyond the end of the core, clearly demonstrating the susceptibility of this portion of the insulation to damage by mechanical displacement of the end-winding structure. In all 16 cases puncture was found to have occurred where the wall insulation had been strained by the movement of the conductors due mainly to circumferentially-directed forces. Subsequent analysis, in fact, showed that it was this component of the short-circuit forces which produced the greatest deterioration in windings having a conical configuration.

A REPLICA STATOR

To discover means whereby the performance of any system of end-winding support could be assessed before its incorporation into a machine, a full-sized replica stator was made, in which different forms of end-winding support were employed. This stator was subjected to instantaneous three-phase short-circuit tests, the short-circuit being timed to occur at the point on the voltage wave which resulted in the greatest forces at particular positions of the winding. A range of current values was chosen equivalent in magnitude to those resulting from short-circuits at various voltages up to 100 per cent. on the original machine. Oscillographic records were taken of all relevant electrical quantities and also of the mechanical movement of the stator conductors relative to the core plate and frame at eight positions. The alternating flux densities at various points in the end-windings were recorded and ciné-cameras were used to view the whole of the end-windings and the core-end-to-knuckle region of those conductors, which were expected to experience the greatest forces.

The movement-recording devices showed that up to currents equivalent to a short-circuit from 50 per cent. voltage elastic deflections occurred on the conductors, but there was no permanent deformation. In tests with currents equivalent to short-circuits at 75 per cent. and 100 per cent.

voltage the amplitude of the oscillations was greatly increased and there was some permanent deformation. At the conclusion of the tests the insulation successfully withstood twice the working voltage plus 1 kV, both between phases and to earth.

EFFECT OF THE ROTOR DURING A SHORT-CIRCUIT

During a short-circuit the form of the magnetic fields in the end-winding region is modified by the presence of the rotor and, in particular, by the eddy currents in the retaining rings. As a result of investigations it was concluded that with the rotor in position the initial peak circumferential forces were lower during short-circuits, whereas the corresponding radial forces were higher. As the circumferential forces were responsible for the major damage to the insulation, no attempt was made to include rotor effects during the experimental winding short-circuit tests.

When arc resistance and decrease in asymmetry were taken into account a reduction in the short-circuit current to about 66 per cent. of the theoretically worst case might be expected. Since the forces varied as the square of the current, these would be reduced to less than half the theoretical peak values. Even if a machine were inadvertently closed on to a system 180 deg. out of phase the highest short-circuit current would only be about 90 per cent. of that resulting from a solid short-circuit on the generator at normal voltage with a corresponding reduction to about 66 per cent. of the forces on the conductors.

In conclusion, the authors remarked that if it were still felt that stator windings should be proved capable of withstanding a solid short-circuit of the machine voltage on open circuit, such proving might well be applied not to the actual windings but to a short-cored, but otherwise full-scale, replica. The use of such a replica would ensure that the windings of the machine as delivered were in new condition and would, in addition, permit testing to destruction to be carried out, thus providing designers and users with an indication of the margins available. Cinematograph records showed the undesirability of subjecting coils and insulation to forces appreciably greater than they were likely to experience in service.

HIGH-PRESSURE BOILERS

PAST AND PRESENT DEVELOPMENTS AND FUTURE TRENDS

The development of high-pressure boilers since 1917 was outlined, and present-day power-station practice discussed, in a paper read by Mr. T. Carlile before the Institution of Engineers and Shipbuilders in Scotland on Tuesday, December 14.

In 1917, said the author, ten boilers were installed at the North Tees station and these might be regarded as the first high pressure boilers in this country. Each had an evaporation of 52,000 lb. per hour at 475 lb. per square inch and were stoker-fired. They were all cross-connected and thus each was able to serve any turbine. Much had been done since then to improve design and increase availability, and between the wars many boilers were operating at pressures of over 1,000 lb. per square inch. As materials for high-temperature service became available turbine designers developed larger units capable of operating at higher temperatures and pressures. A single boiler in place of two or more to supply each set had also resulted in a lower capital investment.

ADVENT OF RE-HEATING

Increased pressures improved the efficiency of the Rankine cycle, but this step by itself led to an increase in the moisture of the exhaust steam with resultant blade erosion. Moisture could be reduced by raising the temperature and this had been rendered possible by the development of alloy steels. Improvement in the means of producing a high vacuum had also helped cycle efficiency. In the early 1930's steam temperatures, however, were limited to about 750 deg. F. by the materials available, so that in the 600 lb. per square inch cycle re-heating was employed to reduce the moisture content of the steam. The result was complex piping arrangements and a separate boiler was often necessary for re-heating. As improved materials for use in superheaters became available and higher initial temperatures possible the use of re-heating was discontinued. When it was re-introduced after the war the size of the boilers had increased and the re-heater could be incorporated in the same setting, thus reducing the first cost and the problem of temperature control. At the same time, increased pressures and temperatures resulted in a lower specific volume which, with the easing of the re-heater pressure drop, enabled more reasonable piping dimensions to be used.

In the main, units were now operating at 900 to 950 lb. per square inch, but had increased in size; and the trend towards single-boiler single-turbine installations was most pronounced. Several 120-MW machines were being installed and would operate at 1,500 lb. per square inch and 1,000 deg. F. with some units incorporating re-heating to 1,000 deg. F. One station was planned to have 200 MW turbines with steam at 2,350 lb. per square inch, superheated to 1,050 deg. F. and re-heated to 1,000 deg. F.

SOME DESIGN CONSIDERATIONS

Although the heat lost by the flue gases to the chimney could be reduced theoretically to a very small amount by the addition of an infinite amount of heat-exchange surface in the economiser and air heater, practical considerations limited the outlet gas temperature to between 250 deg. and 300 deg. F. Careful design of the casings and insulation had reduced the heat lost by radiation to a minimum, while the design of the furnaces and burners had similarly reduced the heat lost in unburnt carbon. Thus, for any set of steam conditions and boiler size the efficiency was almost standard; and it was left to the designer to reduce the temperature of the flue gases by arranging the heating surface.

In the radiant type of boiler, one of which was now being constructed to supply 830,000 lb. of steam per hour to a 100-MW turbine at a pressure of 1,600 lb. per square inch and a temperature of 1,060 deg. F. there was no convection heating surface and the furnace walls, which were of bare tube tangent construction, were used to absorb heat to evaporate the water. In order to maintain high availability the furnace had a low heat release with a long flame travel from the pulverised-fuel burners to the superheater inlet, so that in its passage the gas temperature was sufficiently reduced. There was an arch in the rear wall to create turbulence and to distribute the gases across the superheater inlet. The superheater and economiser were accommodated at the top and rear of the furnace and were surrounded by a steam-cooled surface, giving a compact layout with the minimum of refractory exposed to gases.

FURNACE PERFORMANCE

All large boilers in this country evaporating more than, say, 300,000 lb. per hour were, with few exceptions, fired with pulverised coal in a dry-bottom furnace, the type of burner employed depending on the coal and the shape of the furnace. Several cyclone-fired boilers were, however, being installed.

Furnace performance depended on the maintenance of a tight casing and boiler setting. This was now made easier by the decrease in the amount of brickwork. For a given fuel and method of firing, the furnace absorbing surface must be proportional to the capacity of the boiler, in order to maintain a given outlet temperature. The additional surface required could be provided without increasing the outside dimensions by introducing a division wall into the centre of the furnace. Such a wall also allowed greater latitude in the arrangement of height and width, so that the superheater and re-heater surfaces could be disposed to the best advantage. Further, it reduced the temperature in the centre of the furnace. It could not, however, be used with high-chlorine coal.

In recent years boilers operating under furnace pressure had been installed. In such units the furnace must be capable of withstanding a positive pressure; but only a forced-draught fan was required, erosion problems were overcome, the excess air could be kept to a minimum, with a resulting reduction in the flue-gas heat loss, and the combustion-control equipment cost less.

In boilers operating below the critical pressure it was necessary to provide means for separating the steam and water mixture leaving the furnace and convection surfaces before it entered the superheater. The most satisfactory method of doing this was by centrifugal force.

HEAT-EXCHANGE PROBLEMS

In a large high-pressure, high-temperature boiler as much as 50 per cent. of the heat in the flue gases might have to be transferred to the steam in the superheater and re-heater. Thus, the higher the gas temperature at the superheater inlet the less the surface required. Higher temperatures, however, increased the likelihood of deposit formation and, in addition, the maintenance of high superheater and reheater temperatures at reduced loads had to be considered. This was met by designing the superheater and re-heater surfaces for partial loads and using attemperation, gas circulation or gas by-passing at higher loads. The problem of temperature control must be carefully studied, the heating surface must be arranged in the most economical manner and choking must be reduced to a minimum by widely spacing the tubes and installing sufficient soot-blowing equipment. With the advent of increased stage heating of the feed water and the extraction of a high proportion of heat from the flue gases in the furnace, superheater and re-heater, the economiser of a modern unit was fairly small.

FUTURE TRENDS

During the last few years there had been a trend towards designing boilers to operate at pressures of from 1,500 lb. to 2,000 lb. per square inch; and undoubtedly future central-station installations in this country would be in this class. In order to obtain the increased cycle efficiency at pressures above the critical, that is above 3,226 lb. per sq. in., the whole design was changed, as there was no difference in the density of the water and the saturated steam. Thus, the separation of steam and water was no longer required. About 65 per cent. of the heat transferred was used in superheating and re-heating the steam and, in order that this might be accomplished, and yet the gas temperatures at the superheater inlet be low enough to avoid trouble, a radiant surface was imperative.

The problem of feed-water treatment was important as at the point where the fluid changed to steam there was always a likelihood of solids being deposited on the tube or of active oxidation taking place. For this reason it was essential that the transition zone should be kept in an area of low gas temperatures so that should any deposits be formed the tube-metal temperatures would not be high. Arrangements would have to be made for the periodic washing of internal circuits and the automatic controls were more complicated. Such units represented almost the maximum efficiency that could be obtained with the Rankine steam cycle.

THE ANDRITZ OIL ENGINES

EFFICIENT TWO-STROKE DESIGNS FOR STATIONARY OR MARINE DUTY

By Professor S. J. Davies, D.SC.(ENG.), PH.D., M.I.MECH.E.

Although the general tendency in oil engine practice is towards higher speeds of revolution, there remains a wide field of application in which extreme reliability over long periods of running is associated with relatively low speeds. This field includes, in particular, engines for the propulsion of ships and for the generation of electrical power. The engines that are the subject of the present report were designed with such applications in view by the Anstalt für Verbrennungsmotoren Professor Dr. H. List, consulting engineers, Graz, Austria, for the Maschinenfabrik Andritz, A.G., also of Graz.

They have a cylinder bore of 230 mm. (9·05 in.) and a piston stroke of 340 mm. (13·39 in.), and work on the two-stroke cycle. With a rated B.M.E.P. of 65 lb. per sq. in., they develop normally, over the speed range from 350 to 530 r.p.m., from 50 to 75 b.h.p. per cylinder. With cylinders from 4 to 12 in number, the engines thus cover the range from 200 to 900 rated horse-power. For marine propulsion, the engines are suitable for inland and coastal vessels and for fishing vessels, and are directly reversible. Their other applications, in addition to the generation of electrical power, on land or as auxiliaries on shipboard, include the driving of pumps and of small locomotives. The principal features of the design will first be described; an account will then be given of tests carried out by the author on a four-cylinder unit at the works of the Andritz Company; lastly, the performance and characteristics of the engines will be discussed.

Before considering the details of the design, however, it should be mentioned that, while in the four-cylinder engine the cylinders are arranged in line, in order to start from any crank angle, in the other units they are to be arranged with their axes in V-form. Also, in deciding upon the dimensions of the parts in all units, conformity with the rules of Lloyd's Register and the other leading registration authorities was regarded as essential.

Fig. 1 shows a side view of the four-cylinder engine looking generally towards the air compressor, and Figs. 2 and 3 give transverse and longitudinal sectional elevations, respectively. The swept volume per cylinder is 14·1 litres (861·5 cub. in.). The compression ratio, based on the swept volume, is 20·8 : 1, and the real compression ratio, based on the total volume above the top of the exhaust ports, is 15 : 1. The engine weighs approximately 5,600 kg. (12,320 lb.). The author did not himself observe these values.

DESIGN FEATURES

The admission of the air and the exhaust of the gases take place through ports in the cylinder wall controlled by the piston, no valves or valve gear being employed. The air from the atmosphere, after passing through a filter, enters the centrifugal blower on the left side of Fig. 3, and is delivered through a manifold to reservoirs surrounding the cylinders, from which it enters the cylinders through the admission ports. The ports for each cylinder are arranged symmetrically about a transverse plane; there are four admission ports on each side and, as may be seen in Fig. 3, these give an upward direction to the air. There are three exhaust ports, also to be seen in Fig. 3, which lead the exhaust gases into a common exhaust manifold running along the cylinders. This arrangement provides for loop scavenging in the cylinder, the streams of entering air converging as they pass upwards towards the cylinder head, and then, after completing their loop motion, passing outwards horizontally through the exhaust ports. This is, incidentally, a type of scavenging in which the engineers of the List organisation have had comprehensive experience.*

The advantages of loop scavenging are, first, that the elimination of valves and their gear leads to simpler and cheaper manufacture; second, there is less risk of breakdown and easier maintenance; and third, the cylinder heads are simpler, their cooling can be better controlled, and the thermal stresses are less complicated. Two drawbacks are, first, that the timing of the admission and exhaust ports is symmetrical and, second, that the rates of opening and closing of the ports are determined by the movement of the piston and, apart from the timing, areas and forms of the ports, their operation cannot be arbitrarily changed by the designer. Both drawbacks can be largely overcome by correct design of the charging and exhaust system.

The form of the combustion chamber can be seen in Figs. 2 and 3, and combustion is seen to be of the direct-injection type. The top of the piston is plane and, with the chamber in the cylinder head, the designer had considerable freedom in choosing its form. The form chosen, as will be seen from the test results, led to high thermal efficiency. The cylinder heads are of cast iron. The pistons are of an aluminium-silicon alloy, and each is provided with five pressure rings at the top and three oil-scraper rings at the skirt. The openings into the cylinder head for the fuel-injection nozzle, the air-starting valve, and the relief valve, respectively, can be seen in Fig. 2. The injection nozzles have six holes, each 0·35 mm. in diameter and 0·5 mm. long, arranged with their axes on a cone angle of 105 deg. The fuel pump is fitted with a governor with speed adjustment and, with the injection nozzles and relief valves, was made by Friedmann and Maier, Hallein, Austria.

The crankcase bodies are of cast iron and, as shown in Figs. 2 and 3, are continued down well below the axis of the crankshaft. This gives a very rigid construction which, in spite of relatively small wall thicknesses, makes it possible to withstand, with very small deflections, the various forces imposed in service. Large openings on both sides of the crankcase afford good accessibility to the running gear. The oil sump is of sheet steel. The cylinder liners are of special grey iron and are inserted into the crankcase body. The cylinder heads are secured by studs and nuts to the cylinder liners; the latter are free to expand downwards in the usual way, rubber rings providing a seal for the cooling water. The upward forces on each cylinder head are transmitted by four tension bolts to the crankcase body.

* See ENGINEERING, vol. 172, page 1, (1951); vol. 173, pages 738, 768 and 802, (1952); vol. 176, pages 385 and 419 (1953). See also vol. 176, page 519 (1953).

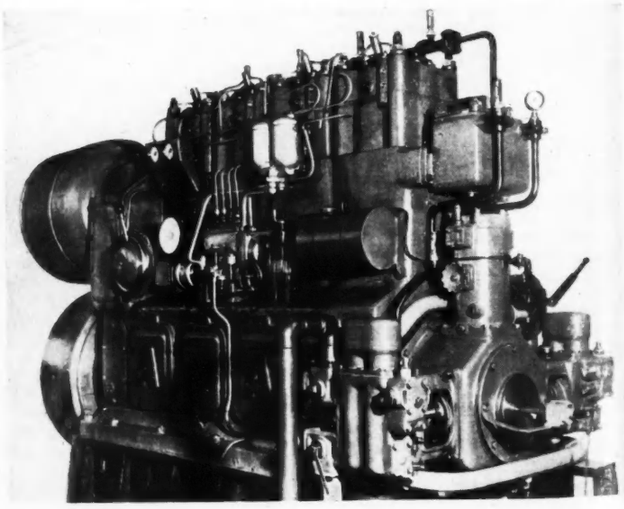


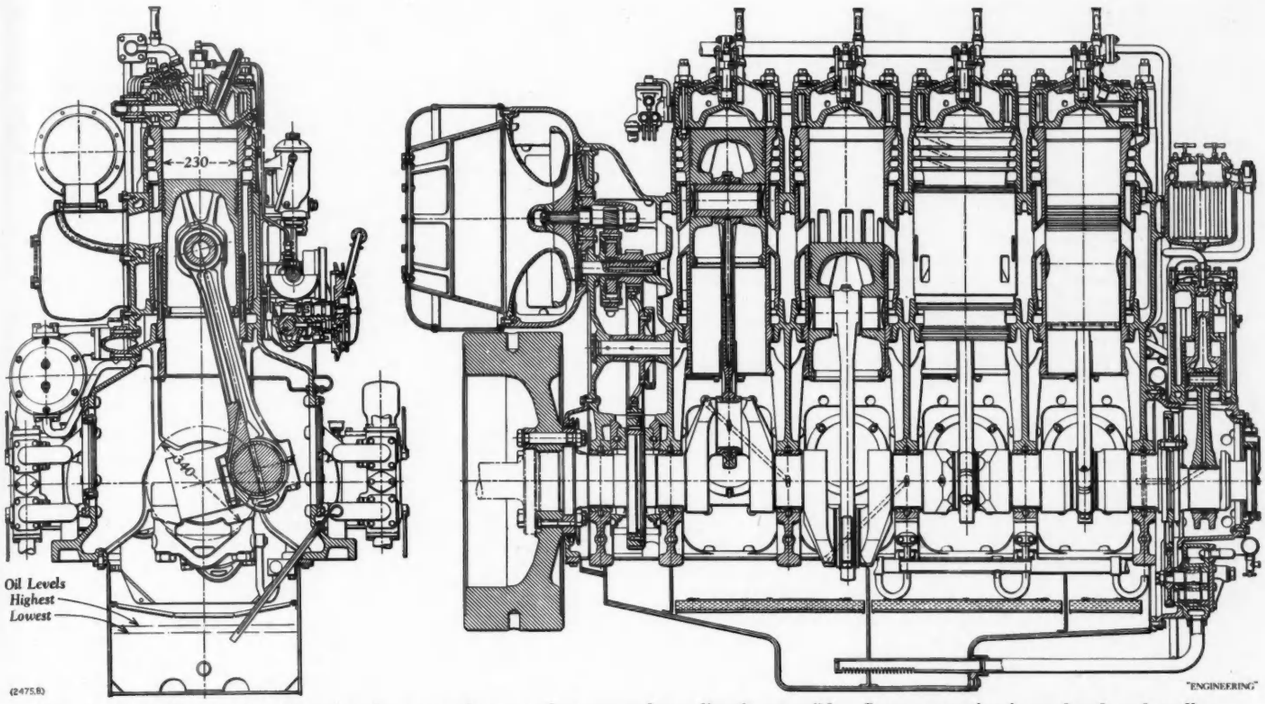
Fig. 1 The four-cylinder in-line engine is one of a range with up to 12 cylinders and rated from 200 to 900 horse-power. The marine version is shown here but the engines are also suitable for driving pumps and small locomotives, and for generating electric power.

COOLING ARRANGEMENTS

Special care was given to the cooling of the engine. When used for marine propulsion a gear casing is provided at the end remote from the flywheel, and in this are accommodated the two-stage air compressor for the starting air, the bilge pump, and the water-circulating pump. Both pumps are of the plunger type. These components can be seen in the foreground of Fig. 1. The engine may be cooled directly with sea water. The cooling water is delivered by circulating pump first through the oil cooler, whence it flows through a pipe, carried along the crankcase, to the individual cylinder liners.

The efficient cooling of the liners is of special importance in two-stroke engines with port scavenging, and the present design includes some interesting features. It is seen in Figs. 2 and 3 that the water jacket is continued well down the liners below the ports, so that heat continues to be lost from the piston, through the pressure rings and the liner, to the cooling water during the considerable crank-angle in which the piston is at or near bottom dead centre. The cooling water enters the annular space in the jackets near the bottom of the liners and then flows upwards through the passages between the admission and exhaust ports, and through the passages provided in the lands between the individual exhaust ports. Above the ports, the water first flows through the second annular part of the jacket, and then through the upper part which is arranged with ribs to form a helical passage having four turns. In the helical passage the velocity of the water is specially high, thus ensuring a vigorous extraction of heat from the liner. From the passage the water enters the cylinder heads and is led away through the pipes seen near the fuel nozzles. The pipe from each cylinder head is fitted with a thermometer and at the entry of the water to each head a regulator is provided which facilitates the equalisation of the cooling of the individual cylinders. With such efficient extraction of heat from the liners, no further provision is necessary for cooling the pistons.

In designing the cooling-water system, particular attention was given to ease of cleaning the passage and removing any deposits. When a vessel in which the engine is fitted is navigating waters in which there is a possibility of excessive deposits collecting in the water jackets, it is possible, by means of a special valve and piping arrangement, to reverse the direction of flow



Figs. 2 and 3 The Andritz oil engines have no valves or valve gear and are directly reversible. Loop scavenging is employed, and cooling can be directly with sea-water.

temporarily and so to remove the deposits while the engine is running.

MECHANICAL PARTS

Considering next the other mechanical parts of the engine, it may be mentioned that both the connecting rods and the crankshafts are of chrome-molybdenum steel and are drop-forged. The crankshafts are designed so that they can be adapted for either the four-cylinder in-line engine or the eight-cylinder V-engine; the design of the connecting rods is the same for all engines. These measures offer obvious advantages from the point of view of cheapening production. In the V-engines each crankpin carries the big-ends of a pair of connecting rods side by side. The main and crankpin journals of the crankshaft are flame-hardened. All bearings of the crankshafts are of lead-bronze in steel shells. The thrust bearings of engines used for marine propulsion are of the Michell type, and are built into the engines so that a bearing external to the engine is not required. The thrust bearing is situated between the two bearings at the flywheel end and is arranged so that the individual bearing segments may be changed without dismantling the crankshaft. In applications in which a thrust bearing is unnecessary, it is replaced by an ordinary bearing which, however, provides for the axial location of the crankshaft.

LUBRICATION

Lubrication of the engine is effected by two separate oil systems. In one system, the pistons are lubricated directly with oil led from a special lubricating pump to the bottoms of the cylinder liners. The pipes and two of the three passages leading the oil to the liners may be seen in Fig. 2. In the second and main system, oil is circulated under pressure to the bearings of the crankshaft, the connecting rods, the scavenging pump, and to the gearwheels driving the scavenging blower. The oil pump, to be seen in the bottom right-hand corner of Fig. 3, is of the gearwheel type, and is of course arranged to give the same direction of flow whether the engine is running ahead or astern. The pump draws oil from the sump and delivers it through an oil cooler and a combined laminar and sieve filter to the main distributing pipe in the crankcase. Magnetised rods are provided in both the suction and delivery pipes upstream of the filter to extract any steel chips or particles from the oil.

The crankshaft main bearings are each supplied with oil from the delivery pipe and the big-end bearings are supplied through holes drilled in the crankshaft in the usual way. The gudgeon pins run in phosphor-bronze bearings and receive oil through a central hole in the connecting rods, this hole being fed from two inclined holes which receive oil from the sides of the big-end bearing which are not under pressure. In this way the important surfaces of the big-end bearings are without holes and the oil pressure is not affected. In order to avoid over-lubrication of the pistons by splash from the big-end bearings, the latter are provided with circular spaces at the sides in which the oil leaking from the bearings is collected; these release the oil downwards towards the sump through holes on the side remote from the pistons.

The gearwheel drives at the flywheel end of the engine for the scavenging pump and the fuel-injection pumps are supplied with oil from the main distributing pipe, at the end of which a regulating valve is fitted. The individual bearings receive oil partly through drilled holes and partly through pipes that are arranged to be free from vibration. The oil supply to the air compressor, and to the bilge and circulating-water pumps, is conveyed through holes drilled in the crankshaft.

SCAVENGING BLOWER

The scavenging blower is of the centrifugal type and is located above the flywheel, as shown on the left in Fig. 3. It is driven from a gearwheel on the crankshaft by a first intermediate wheel of equal size, and then through a countershaft, fitted with two gears and an elastic damping coupling, which give a speed increase to 18·7 times the crankshaft speed. The resonance speed of this coupling is quite low and when this speed is exceeded the whole is in the supercritical range. The delivery air passes through the manifold seen on the left in Fig. 2.

The individual outlet passages from the exhaust ports pass across the same manifold on their way upwards to the exhaust manifold, the passages being provided with double walls between which heat-insulating material is inserted. Access to the admission ports is obtained through hand-holes fitted with cover plates.

REVERSING GEAR

A special advantage of the two-stroke cycle, particularly with symmetrical port scavenging and a reversible blower as in this case, is the simplicity of the reversing gear. For reversing it is only necessary to rotate the common driving cams for the valves which control the supply of starting air to the valves in the cylinder heads, while in the drive to the injection pumps it suffices to introduce a slip-coupling which gives the correct angle of injection in both directions.

A single lever thus serves for reversing the engine and, according to its position, effects first the starting with compressed air and then the running of the engine under power in the desired direction. The complete reversing operation is therefore brought about by the reversing unit connected to the lever. This unit not only moves at the proper instant the cams for the starting air into the position for the desired starting speed, but also actuates the slip-coupling in the drive to the injection pumps. This slip-coupling consists of a cylindrical part with a sector cut out. In the resulting space a stop fixed to the housing is arranged to limit the angular motion of this cylindrical part relatively to its housing. In reversing, the cylindrical part is turned by compressed air into one or other of its end positions. In the running position, the reversing unit connects the slip-coupling and the oil-circulating system, so that the cylindrical part is held against the stop by the pressure of the oil. In reversing, which also takes place with the aid of compressed air, the lubricating oil must be forced out by the movement of the cylindrical part, and by this means a very effective damping is brought about of what would otherwise be an undesirably violent rotation of the slip-coupling.

Thus the difficulties commonly met with in the use of a slip-coupling are completely obviated. The speed of the engine is set by a handwheel through which the tension of the springs of the rotating masses of the governor is changed. Finally, the simplicity of the method of reversing

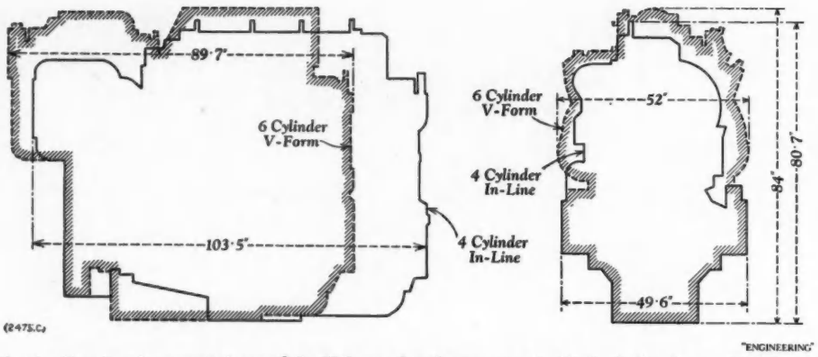


Fig. 4 Showing the compactness of the V-form of engine compared with the in-line form. Weight and production costs are reduced.

and controlling the speed of these engines renders possible direct control from the bridge of a ship.

The governor itself is integral with the fuel-injection pump. The device for the lubricating oil to the cylinder liners, previously mentioned, is connected directly to the governor, and delivers fresh oil directly to the liners through the passages shown in Fig. 2. The quantities of oil delivered to the separate cylinders are regulated in accordance with the load on the engine by coupling the lubricating device to the regulating rods of the injection pump. In this way over-lubrication at light and part loads is prevented.

All the auxiliaries required by the engine, such as the injection pump with its governor, the bilge and circulating-water pumps, the air compressor, the gear for supplying the pressure air and for reversing, the scavenging blower, the filters for the fuel and for the lubricating oil, the cooler for the lubricating oil, etc., are integral with the engine, and, once the various connections for the cooling water, fuel supply, and exhaust are made, the engine is ready for service.

COMPARISONS OF IN-LINE AND V-FORM DESIGNS

Some interesting points arise when the four-cylinder in-line engine is compared with the six-, eight- and twelve-cylinder engines which are in V-form. The overall dimensions and weights for the four types are shown in Table I. The advantages in overall dimensions of the six-cylinder engine in comparison with the four-cylinder engine can be appreciated by the sketches in Fig. 4. The shortening of the engines resulting from the V-form, while desirable in itself in marine applications, has the advantage of cheapening the production. Not only is there the saving of half the cranks in the crankshaft compared with an in-line engine, but the reduction of weight brings with it a considerable reduction of production costs. By taking 45 deg. as the angle of the V, not only is the width of the engine reduced, but accessibility to the main and connecting-rod bearings through the crankcase openings is facilitated. The auxiliaries can be conveniently arranged at the flywheel end of the engine, where they are readily accessible. The only part carried in the V is the exhaust manifold, which does not require special attention. The manifolds for the scavenging air are fitted on the outsides of the cylinders. With the common size of cylinder, the weights of the cylinder heads, liners, pistons and connecting rods, which are lifted upwards when dismantling, cause little difficulty. In considering the total weights of the engines it must, of course, be borne in mind that they are inclusive of all auxiliaries and reversing gear. They would be reduced considerably if the engine bodies were of welded construction instead of iron castings.

TABLE I.—*Dimensions and Weights of In-Line and V-Form Engines*

No. of cylinders	4 (in line)	6 (V-form)	8 (V-form)	12 (V-form)
Length, in. ..	103·5	89·7	104	132·3
Height, in. ..	80·7	84	84	84
Width, in. ..	49·6	52	52	52
Weight, lb. ..	12,320	13,650*	15,620*	18,710*

* Estimated.

METHODS OF TESTING

The tests carried out on the four-cylinder engine were made with two principal objects in view, namely, to investigate the performance of the engine in relation to its possible applications, and to obtain information concerning the working of the reversing gear. The first tests consisted, therefore, of series at constant speeds, 350, 400, 450, 500 and 530 r.p.m., the loads in each series being varied from light to full.

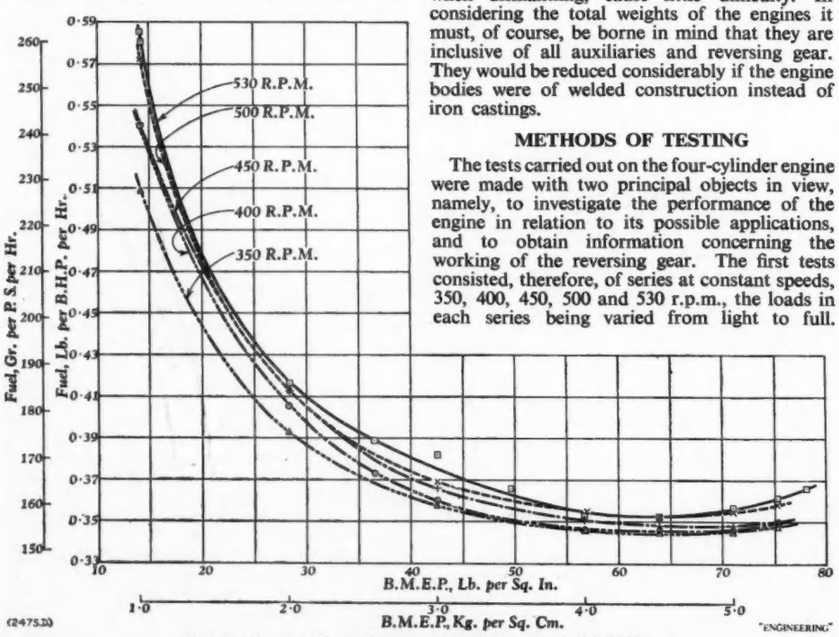


Fig. 5 Curves of specific consumption against B.M.E.P.

The principal data from these tests are given in Table II, and are derived from observations of the brake torque, revolutions per minute, and fuel consumption. The power developed by the engine was measured by means of a hydraulic dynamometer. This was afterwards uncoupled from the engine, its zero balance was checked and the readings of the spring balance were calibrated by adding weights and found to be without appreciable error. In Table II the brake torques have been converted into the equivalent values of B.M.E.P.

TABLE II.—*Test Data*

Test No.	R.p.m.	B.M.E.P., lb. per sq. in.	B.h.p.	Fuel, lb. per hour	Fuel, lb. per b.h.p. per hour
A 1	535	2·3	—	24·4	—
A 2	535	14·2	66	38·7	0·585
A 3	535	14·2	66	38·3	0·581
A 4	537	28·4	133	55·0	0·416
A 5	534	35·5	166	64·3	0·389
A 6	532	42·6	198	75·7	0·382
A 7	530	49·7	230	84·0	0·366
A 8	532	56·8	263	93·1	0·353
A 9	532	64·0	296	104·2	0·352
A 10	529	71·1	327	116·4	0·356
A 11	530	75·3	347	125·0	0·361
A 12	531	78·2	361	132·0	0·366
B 1	499	2·4	—	21·9	—
B 2	503	14·2	62	35·4	0·572
B 3	501	28·4	124	51·3	0·413
B 4	502	42·6	185	68·2	0·369
B 5	502	57·0	249	88·5	0·355
B 6	505	64·0	281	98·8	0·352
B 7	502	71·1	310	110·0	0·355
B 8	502	75·3	329	118·0	0·358
C 1	452	1·5	—	18·1	—
C 2	452	14·2	56	30·0	0·541
C 3	452	28·4	111	46·5	0·413
C 4	454	42·6	168	61·6	0·366
C 5	454	56·8	225	78·5	0·351
C 6	453	64·0	252	87·3	0·348
C 7	452	71·1	280	95·1	0·348
C 8	452	75·3	296	104·0	0·350
D 1	402	1·5	—	14·9	—
D 2	399	14·2	49	26·8	0·540
D 3	403	28·4	100	40·3	0·405
D 4	409	36·6	130	48·2	0·373
D 5	403	42·6	150	53·9	0·360
D 6	402	56·8	199	68·8	0·346
D 7	401	64·0	224	77·4	0·346
D 8	399	71·1	246	85·1	0·348
D 9	402	75·3	264	92·0	0·350
E 1	344	2·5	—	11·5	—
E 2	345	14·2	42·6	21·6	0·509
E 3	348	28·4	86·0	33·8	0·393
E 4	349	42·6	129·0	46·4	0·358
E 5	350	56·8	173·0	60·1	0·346
E 6	351	64·0	196·0	67·5	0·345
E 7	351	71·1	217·0	74·8	0·345
E 8	349	75·3	229·0	79·5	0·348

While a tachometer afforded a continuous check of the constancy of the speed of revolution, the counting of the revolutions and the fuel consumption were simultaneously observed. The time to consume a measured volume of fuel was taken by a stop-watch; the counter, which received an electrical impulse once every revolution through a contact on the dynamometer shaft, was switched on at the instant when the consumption of the measured volume of fuel commenced, and switched off immediately this volume had been consumed. The quantity of fuel to fill the measured volume was weighed and from the times, as observed by the stop-watch during the tests, the fuel consumption in pounds per hour and the revolutions per minute of the engine were calculated. The oil leaking from the injection nozzles drained directly to the suction pipes of the fuel pump and thus did not need to be observed. The rate of flow of the circulating water was adjusted to give in all tests an outlet temperature of roughly 170 deg. F. (77 deg. C.).

During the tests the barometer stood at 29·1 in. (739 mm.) of mercury and the room temperature was low at 45 deg. F. (7 deg. C.). The gas oil used in the tests was of Austrian origin. It was submitted for test to Dr. F. Zemek, of the Department of Chemistry, Technische Hochschule, Graz, from whose report the following data are taken: specific gravity, 0·872 at 60 deg. F. (15·4 deg. C.); carbon, 86·86 per cent.; hydrogen, 13·11 per cent.; lower calorific value, 17,490 B.Th.U. per lb. (9,714 kcal. per kg.); and higher calorific value, 18,770 B.Th.U. per lb. (10,425 kcal. per kg.). The lubricating oil used was Gargoyle DTE No. 3D, of the Socony

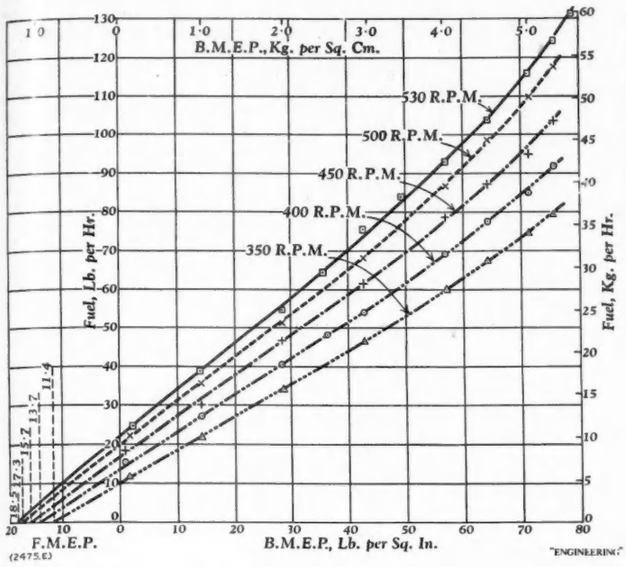


Fig. 6 Curves of consumption per hour against B.M.E.P., from which the mechanical losses, expressed as frictional mean effective pressure (F.M.E.P.), are derived.

Vacuum Petroleum Company, of specific gravity 0·905 and viscosity 8·82 Engler (270 sec. Redwood Standard) at 112 deg. F. (50 deg. C.).

TEST RESULTS

The data obtained in the tests are plotted as specific consumption, in lb. per brake horse-power per hour, on a base of B.M.E.P. in Fig. 5. It is seen that the curves for this series of speeds, in which the highest speed is over 50 per cent. greater than the lowest, all lie within a very restricted range. The value of the B.M.E.P. at rated full load is 65 lb. per square inch, at which the lowest consumptions are recorded at all speeds. These consumptions lie between 0·345 lb. and 0·352 lb. per brake horse-power per hour, and are very low for a two-stroke port-scavenged engine. At half-load, the values lie at or below 0·4 lb. per brake horse-power per hour, and are again very favourable to good economy. Although the state of the exhaust was observed throughout, separate series of observations with gradually increased loads were carried out at the higher speeds; in these, observations were made of the total exhaust against a grey sky and separate observations were made of the exhaust from each cylinder into the room. The "limit of satisfactory exhaust," as given by the commencement of visibility, was seen to be at 75 lb. per square inch. This represents a margin of 15 per cent. over the rated B.M.E.P.

MECHANICAL LOSSES

In order to obtain information concerning the mechanical losses of the engine, and thus to make deductions concerning the indicated performance, the hourly consumptions of fuel were plotted on a base of B.M.E.P., as shown in Fig. 6. The points on such curves are straight lines from no-load to about half-load, and if these are extrapolated to cut the base line, the intercepts may be taken as the mechanical losses expressed as frictional mean-effective pressure (F.M.E.P.). The values for the five series are given in Fig. 6, and are plotted on a base of r.p.m. in Fig. 7; the values fall roughly on a straight line. Curves of this kind shown in Fig. 6, in addition to affording such information, are of value in showing whether the test results are consistent among themselves. In the present series, the small deviations of the observations from the curves indicate the high accuracy of the readings during the tests.

Table III gives the actual data at the nearest tests to the value of B.M.E.P., 65 lb. per square inch, corresponding to the rated brake horse-power at the various speeds in the range from 350 to 530 r.p.m. In all these tests the brake torque setting was constant and equivalent to a B.M.E.P. of 64·0 lb. per square inch, as given in the third line. The values of F.M.E.P. are set out in the fourth line, and the values of the sums of B.M.E.P. and F.M.E.P., which, on the assumption of constant values for F.M.E.P. at each speed, give the values of indicated mean

TABLE III.—*Tests at Different Speeds with Constant B.M.E.P.*

Test number ..	A9	B6	C6	D7	E6
R.p.m. ..	532	505	453	401	351
B.M.E.P., lb. per sq. in.	64·0	64·0	64·0	64·0	64·0
F.M.E.P., lb. per sq. in.	18·5	17·3	15·7	13·7	11·4
I.M.E.P., lb. per sq. in.	82·5	81·3	79·7	77·7	75·4
Mechanical efficiency, per cent. ..	77·6	78·8	80·3	82·4	85·0
Consumption, lb. per b.h.p. per hr. ..	0·352	0·352	0·348	0·346	0·345
Consumption, lb. per i.h.p. per hr. ..	0·273	0·277	0·279	0·285	0·293
Overall thermal efficiency, per cent. ..	38·6	38·6	39·0	39·2	39·4

effective pressure (I.M.E.P.), shown in the fifth line. The values of mechanical efficiency are next given and are plotted in Fig. 7; they range from 85·0 per cent. at 350 r.p.m. to 77·6 per cent. at 530 r.p.m. These are very satisfactory results when it is remembered that F.M.E.P. includes the work done by the scavenging blower. The values of the actual brake specific consumptions in these tests are set out, and the values of the corresponding indicated specific consumptions, as calculated from the mechanical efficiencies, are given. They range from 0·293 lb. per indicated horse-power at 350 r.p.m. to 0·273 lb. per indicated horse-power at 530 r.p.m., and are remarkably low. Lastly, as a matter of interest, the overall or brake thermal efficiencies are set out; these, at the rated outputs of the engine, all lie within ± 1 per cent. of 39 per cent.

THERMAL EFFICIENCY

If the straight line portions of the curves in Fig. 6 are considered, it is found that the values of fuel consumption per hour are in direct proportion to those of I.M.E.P., and they are thus lines of constant indicated thermal efficiency. Since the curves diverge upwards from the straight lines with increasing loads, these constant values of indicated thermal efficiency are also maxima. For each series, a test point lying directly on the straight line was chosen and is given in the top line of Table IV, after which, in the next two lines, the actual speeds and values of B.M.E.P. for the particular tests are set out. The same procedure is followed as in the calculations leading to Table III, and the specific con-

TABLE IV.—*Tests Showing Indicated Thermal Efficiency at Different Speeds*

Test number ..	A5	B4	C4	D4	E4
R.p.m. ..	534	502	454	403	349
B.M.E.P., lb. per sq. in.	35·5	42·6	42·6	42·6	42·6
F.M.E.P., lb. per sq. in.	18·5	17·3	15·7	13·7	11·4
I.M.E.P., lb. per sq. in.	54·0	59·9	58·3	56·3	54·0
Consumption, lb. per b.h.p. per hr. ..	0·389	0·369	0·366	0·360	0·358
Consumption, lb. per i.h.p. per hr. ..	0·256	0·262	0·268	0·272	0·283
Indicated thermal efficiency, per cent. ..	53·0	51·9	50·7	49·9	48·0

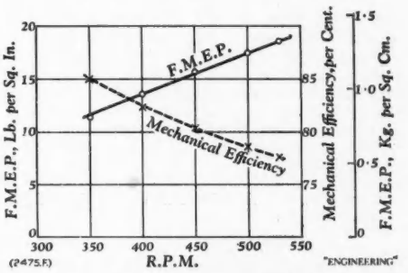


Fig. 7 Curves of friction mean effective pressure and mechanical efficiency against r.p.m.

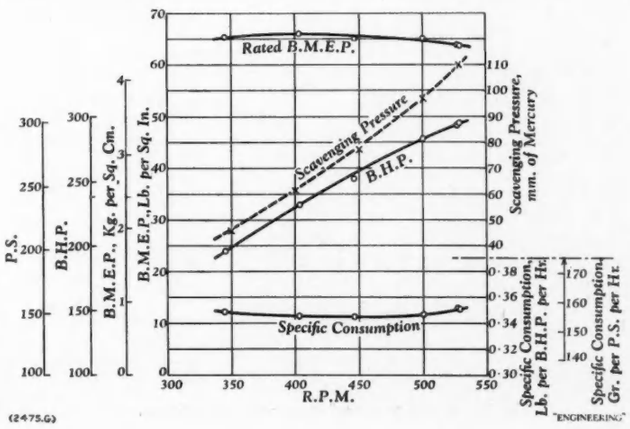


Fig. 8 Curves of B.M.E.P. and specific consumption for rated B.M.E.P. against r.p.m.

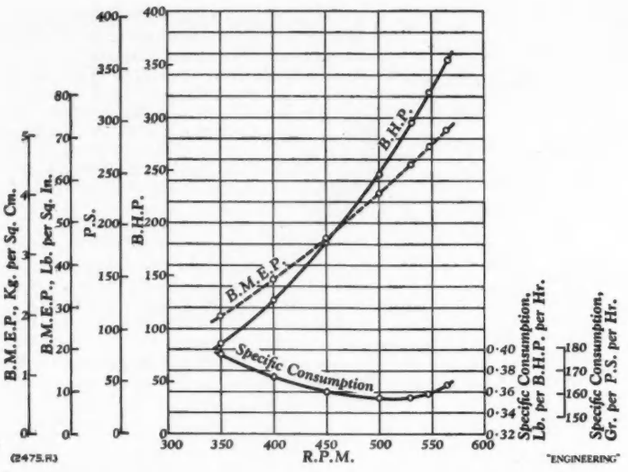


Fig. 9 Characteristics of propeller drive.

sumptions are shown; the last line is added giving, for each series, the corresponding values of the maximum indicated thermal efficiency based on the higher calorific value of the fuel. These values, from 48 to 53 per cent., are so high that it appeared worth-while to compare them with the values theoretically possible.

If the effective compression ratio of 15 : 1 is taken, this is not accurate, since there is some positive work done on the pistons while the ports are open; on the other hand, the total compression ratio of 20·8 : 1 is too high. On the Air Standard Cycle, with $\gamma = 1{\cdot}4$ throughout, the thermal efficiencies corresponding to these two values of the compression ratio are, respectively, 66·1 and 70·2 per cent. Pye,* however, proposed that the value $n = 1{\cdot}33$ should be substituted for $\gamma = 1{\cdot}4$, in order to take into account the changing specific heats and the dissociation of the gases, the cycle being otherwise an ideal one. With this value the highest practicable thermal efficiency with the actual working substances at a given compression ratio should be given. Pye's results were for a petrol-air mixture 50 per cent. weak, working on a constant-volume cycle, and are thus to be considered as conservative in relation to the present case. Calculations on this basis for these two compression ratios lead to the values 59·0 and 63·2 per cent., respectively. The true ideal value for the present two-stroke engine lies somewhere between these two values. In any case, the differences between the observed values and the practicable ideal value are so small that improvement in the design of the combustion chamber, in order to achieve yet higher values of the indicated thermal efficiency, would clearly be hardly possible.

* Pye, D. R., *The Internal Combustion Engine*, vol. I, page 143.

SPECIFIC FUEL CONSUMPTION

It was thought desirable to run a series of tests over the range of speeds from 350 to 530 r.p.m., with the delivery from the fuel pump limited to give the rated B.M.E.P. The values of specific consumption are of the same order as those to be deduced from Fig. 5 under these conditions, but in order to show in a convenient form the practical performance at the rated outputs, Fig. 8 has been prepared. In this figure rated B.M.E.P., scavenging pressure, brake horse-power, and brake specific consumption are plotted on a base of revolutions per minute. In applying the engine to the propulsion of ships the brake horse-power demanded is, of course, governed by the propeller law. The values of brake horse-power, B.M.E.P., and brake specific consumption, for the case in which the engine gives its full rated B.M.E.P. at 530 r.p.m., are shown in Fig. 9, on a base of revolutions per minute, over the speed range from 350 to 564 r.p.m., the top speed corresponding to 20 per cent. overload. It will be noted that even at one-quarter power the specific consumption is still less than 0·4 lb. per brake horse-power per hour. Finally, all these characteristics of the performance of the engine are combined in a single diagram in Fig. 10. In this, B.M.E.P. is plotted on revolutions per minute; the full lines are lines of constant brake specific consumption; the broken lines show constant brake horse-power; the conditions at the rated B.M.E.P. in normal running, and when following the propeller law, are superimposed.

SCAVENGING AND CHARGING

The results so far recorded were possible only if the scavenging and charging operations were effectively carried out and study was directed to investigating these operations. It had been observed that the variation of scavenging pressure at constant speed over the full range of load was very small, 4 mm. of mercury being the largest variation in any series.

In the absence of means for measuring directly the air consumption of the engine, samples of the exhaust gas were taken under two sets of conditions: the first, after the exhaust gases had been thoroughly mixed in the exhaust box; and the second, by means of a spring-loaded sampling valve which collected, during a number of cycles, the exhaust gas leaving the cylinders in the interval of time immediately after the exhaust ports opened but before these gases could be mixed with the new scavenge air; that is, during the "pre-exhaust" interval. In this interval the pressure of the outflowing gases was sufficient to open the sampling valve against the closing force exerted by its spring. The results obtained by analysing these samples are set out in Table V for three tests in each of the two series F and G, F at 350 r.p.m. and G at 530 r.p.m., the three tests in each series including also measurements of the fuel consumptions

TABLE V.—ANALYSES OF EXHAUST-GASES

Test No.	R.P.M.	B.M.E.P., lb. per sq. in.	Fuel, lb. per B.H.P. per Hour.	Fuel, lb. per Hour	Exhaust Gases During "Pre-Exhaust"		Exhaust Gases After Mixing in the Exhaust Box.	
					CO_2, Per Cent.	O_2, Per Cent.	CO_2, Per Cent.	O_2, Per Cent.
F 1	351	42·6	0·358	46·5	5·8	13·5	2·4	18·0
F 2	351	64·0	0·347	67·7	8·6	10·0	3·5	16·4
F 3	352	71·1	0·347	75·4	9·5	8·7	4·0	15·6
G 1	529	42·6	0·384	75·6	5·4	13·8	2·4	17·9
G 2	531	64·0	0·355	105·0	7·4	10·9	3·4	16·6
G 3	529	71·1	0·360	118·2	8·9	9·0	4·1	15·7

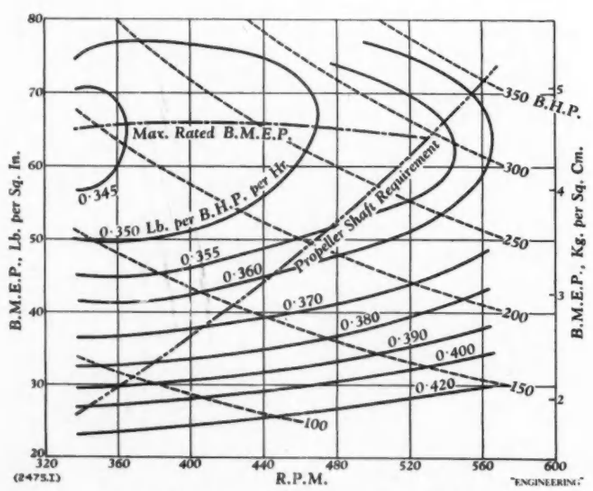


Fig. 10 Diagram of performance characteristics.

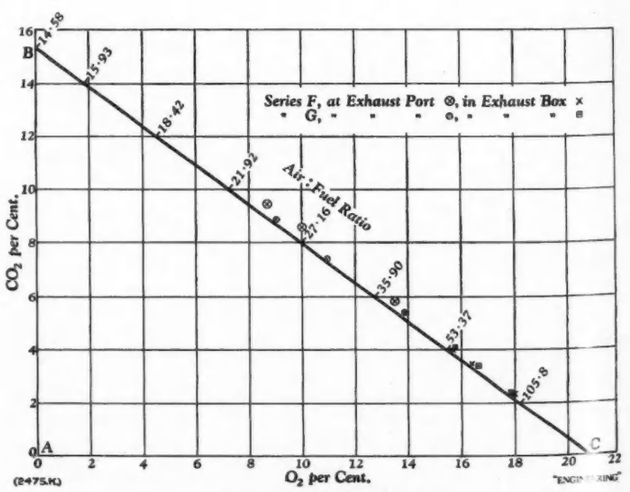


Fig. 11 Combustion triangle.

TABLE VI.—CHARGING PROCESSES

1 Test No.	2 Fuel, lb. per hour	3 Total Air, lb. per hour	4 Gross Volume Efficiency	5 Trapped or "Combustion" Air, lb. per hour	6 Utilisation of Combustion Air	7 Ratio of Combustion Air to Total Air	8 Net Volume Efficiency	9 Swept Weight, lb. per hour
F 1	46·5	4,110	1·273	1,744	0·393	0·425	0·541	3,222
F 2	67·7	4,125	1·279	1,714	0·575	0·416	0·532	3,222
F 3	75·4	4,023	1·245	1,736	0·633	0·431	0·537	3,232
G 1	75·6	6,675	1·373	3,005	0·367	0·450	0·618	4,855
G 2	105·0	6,574	1·348	3,079	0·497	0·468	0·631	4,880
G 3	118·2	6,257	1·289	2,898	0·595	0·463	0·596	4,855

over a range of B.M.E.P. These tests were proposed by the author when he had recorded the very interesting results for the fuel consumptions, but the early attempts with the sampling valve were not satisfactory. Improvements were made to the valve and its position and the results given in Table V were collected after the author's departure by Dr. Mramor of the Technische Hochschule, Graz, in collaboration with the engineers of the List organisation.

INVESTIGATION OF COMBUSTION PROCESSES

Calculation of the air necessary for chemically-complete combustion showed this to be 14·58 lb. per lb. of fuel. With this ratio, the CO_2 produced was 15·32 per cent. by volume of the dry exhaust gases, the remainder, of course, being nitrogen. The combustion triangle shown in Fig. 11 was then constructed, and the points plotted. The test points, with complete combustion of the carbon in the fuel, should lie on the line BC but, owing to experimental error, lie mostly above it. Taking the values of CO_2 rather than the values of O_2 for the points, the corresponding air : fuel ratios were calculated. For the worst point, F2, Table V, this value is lower than that found by taking the value of O_2 by less than 7 per cent.

The data in Table VI using the values of CO_2, were then worked out: the product of the fuel per hour and the air : fuel ratio based on the value of CO_2 after mixing gives the total air (col. 3); the product of the fuel per hour and the air : fuel ratio based on the value of CO_2 from the pre-exhaust gives the trapped air (col. 5); the ratio of the chemically correct air quantity to the actual quantity of trapped air per lb. of fuel gives the utilisation (col. 6); the ratios of combustion air to total air (col. 7) follows from dividing the values in col. 5 by those in col. 3. The values of swept weight given in col. 9 were found from the volumes swept out by the piston in the individual tests, multiplied by the weight per unit volume of the air under room conditions. The values of gross volumetric efficiency (col. 4) are, of course, given by dividing each value of total air (col. 3) by the corresponding value of the swept weight (col. 9), while net volumetric efficiency (col. 8) is found by dividing each value of the trapped air (col. 5) by the corresponding value of the swept weight (col. 9).

The utilisation of the trapped air for combustion is best in Test No. F 3, and has the value 0·633, which corresponds to an air : fuel ratio of 23 : 1. This must be considered good, especially when it is remembered that the load must be increased by 5·5 per cent. to reach the limit of satisfactory exhaust at a B.M.E.P. of 75 lb. per sq. in., the necessary increase in the fuel supply being relatively somewhat greater. This gives further support to the statements made earlier concerning the high quality of the design of the combustion chamber in relation to thermal efficiency. In considering the values of the net volumetric efficiency, it may be recalled that the values of swept weight forming the denominators are based on the total swept volume and not on the swept volume above the ports, which is considerably less than the total. The values of gross volumetric efficiency are of interest, although the values of brake thermal efficiency measured make it clear that, in the design of the complete scavenging system, a sound compromise has been reached, on the one hand, between the quantity of air necessary for the effective scavenging and charging of the cylinders, and, on the other hand, the need to reduce to the limit the work of compression in the blower, which depends both on the air quantity compressed and on the pressure ratio from the atmosphere to the scavenging pressure.

TESTS OF MANŒUVRABILITY

The tests of the reversing of the engine were all made with the engine coupled to the hydraulic brake, which was set to give, at any speed of revolution, the same order of resistance as that which would be offered by the propeller of a ship designed so as to absorb 300 P.S. at 530 r.p.m. This simulated the resistance torque offered by the propeller but did not take into account the axial thrust exerted by the propeller on the thrust bearing of the engine.

The first two tests had two objects: firstly, to establish the rate at which reversals from a slow speed, as when manœuvring in harbour, could be made and, secondly, to determine under these conditions, how many reversals could be made with a compressed-air vessel of 3·18 cub. ft. (90 litres) volume when initially at a certain pressure, and thus to give an idea of the quantity of compressed air which must be supplied. With a gauge pressure in the vessel initially at 430 lb. per sq. in., it was possible to make 12 reversals from and to a speed of 150 r.p.m., all in less than one minute. With a pressure of 570 lb. per sq. in. in the same vessel it was possible to make at least 23 reversals from and to 150 r.p.m., in this case in 2·65 minutes. In both cases the air pressure in the air vessel fell to 115 lb. per square inch. These tests show great rapidity of reversing and a good economy in compressed air. In the third test, observation was made of the time necessary for an emergency reversing operation, without regard to the consumption of compressed air. The engine was driven ahead at full power at 530 r.p.m. and then, on a signal, reversed as quickly as possible and brought up to full power astern at 530 r.p.m. This was achieved in an average time of 11 seconds. These three tests demonstrate the excellent manœuvrability of this design of engine and, in particular, its convenience of operation under the conditions in crowded harbours and in emergency.

CONCLUSIONS

The tests have demonstrated the low fuel consumption of the engines under the running conditions likely to be met with in any kind of application, on land or on shipboard. The manœuvring capabilities of the engines are certainly outstanding. The design is simple and sound. The engines should be relatively cheap to manufacture and should prove to be reliable in service. Altogether, the standard reached in the conception, design and performance of these engines, in the author's opinion, is of a very high order.

LAUNCHES AND TRIAL TRIPS

M.S. "POLARPRINS."—Single-screw oil tanker, built and engined by Barclay Curle & Co., Ltd., Whiteinch, Glasgow, for Hvalfangerselskapet Polaris A/S (Managers: Melsom and Melsom, Larvik, Norway.) Last of a series of three vessels built for these owners. Main dimensions: 557 ft. by 73 ft. 9 in. by 40 ft.; deadweight capacity, about 18,300 tons. Barclay Curle-Doxford six-cylinder oil engine, arranged to burn heavy oil and developing about 8,000 b.h.p. Speed, about 15½ knots. Launch, December 10.

M.S. "OREPTON."—Single-screw ore-carrying vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Ore Carriers Ltd., London, E.C.3. Third vessel of a series of six built by these owners. Main dimensions: 407 ft. between perpendiculars by 57 ft. by 33 ft. 4 in.; deadweight capacity, about 9,000 tons on a draught of 25 ft. 6 in. Two Gray-Polar five-cylinder oil engines coupled to one propelling shaft through Vulcan hydraulic clutches and reduction gearing supplied by David Brown and Sons (Huddersfield) Ltd., Huddersfield. Speed, 12 knots. Launch, December 10.

H.M.S. "RUSSELL."—Anti-submarine frigate, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Admiralty, London, S.W.1. Length, 310 ft. overall; beam, 33 ft. Armament comprises three Bofors guns and two three-barrelled anti-submarine mortars. Propulsion provided by geared steam turbines constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Launch, December 10.

M.S. "AYIA MARKELLA."—Single-screw cargo vessel, built by Bartram and Sons, Ltd., Sunderland, for the (C.M.L.) Maritime Co., Ltd., Chios. Main dimensions: 445 ft. 7 in. between perpendiculars by 62 ft. by 40 ft. 2 in. to shelter deck; deadweight capacity, about 10,850 tons on a draught of 26 ft. 11⅜ in. Kincaid-Harland and Wolff-Burmeister and Wain six-cylinder single-acting two-stroke Diesel engine, developing 4,400 b.h.p. at 115 r.p.m. in service, constructed by John G. Kincaid & Co., Ltd., Greenock. Engine designed to burn heavy fuel oil. Service speed, 13¼ knots. Launch, December 11.

M.S. "PRINCESS ANNE."—Single-screw trawler, built by Cook, Welton and Gemmell Ltd., Beverley, Yorkshire, for the St. Andrews Steam Fishing Co., Ltd., Hull, and the Boston Deep Sea Fishing and Ice Co., Ltd., Fleetwood, under the auspices of the White Fish Authority's scheme. First of three vessels for these owners. Main dimensions: 152 ft. 3 in. overall by 28 ft. by 13 ft. 9 in.; gross tonnage, 390. Six-cylinder marine Diesel engine developing 850 b.h.p. at 250 r.p.m., constructed by British Polar Engines Ltd., Glasgow, and installed by Amos and Smith Ltd., Hull. Launch, December 11.

M.S. "BOSTON NEPTUNE."—Single-screw trawler, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for the Boston Deep Sea Fishing and Ice Co., Ltd., Fleetwood. Main dimensions: 128 ft. by 26 ft. 6 in. by 13 ft. Mirrlees marine Diesel engine, developing 750 b.h.p. at 250 r.p.m., constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Launch, December 11.

M.S. "GRENADA."—Single-screw trawler, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for the Dagon Fishing Co., Ltd., Lowestoft. Main dimensions: 102 ft. 6 in. between perpendiculars by 23 ft. by 11 ft. 3 in.; gross tonnage, 190. Six-cylinder four-stroke compression-ignition Diesel engine, with combined oil-operated reverse-reduction gear, developing 403 b.h.p. at 430 r.p.m. in service. Propelling machinery constructed by Ruston and Hornsby, Ltd., Lincoln, and installed by the Drypool Engineering and Dry Dock Co., Ltd., Hull. Launch, December 13.

S.S. "ARAFURA."—Single-screw cargo vessel, built and engined by Barclay Curle & Co., Ltd., Whiteinch, Glasgow, for the Eastern and Australian Steamship Co., Ltd., London, E.C.3. Main dimensions: 482 ft. by 63 ft. by 39 ft. to upper deck; deadweight capacity, 10,800 tons; gross tonnage, 9,300. Steam turbines with double-reduction and single-reduction gearing, and two oil-burning water-tube boilers. Trial trip, December 14.

M.S. "HELCION."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Shell Tankers, Ltd., London, E.C.3. Main dimensions: 530 ft. between perpendiculars by 69 ft. 3 in. by 39 ft.; deadweight capacity, 17,910 tons on a draught of 29 ft. 9⅛ in.; gross tonnage, 12,091; oil-cargo capacity, 17,467 tons. Steam-turbo electric propelling machinery, developing 7,500 s.h.p. at 100 r.p.m. in service, and constructed by the British Thomson-Houston Co., Ltd., Rugby: comprising two sets of impulse turbines direct-coupled to two-pole alternators, supplying three-phase current for an electric motor directly connected to the propeller shaft. Steam supplied by two Babcock and Wilcox forced-draught oil-burning boilers, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 14½ knots. Trial trip, December 16.

The Dart 506 engines fitted to 18 new Viscount air-liners for Canadian service give a cruising speed higher by 18 m.p.h. than that of earlier Viscounts, and reduced fuel consumption.

VISCOUNT FOR CANADA

Powered by Dart 506 Engines

The first of 18 Viscount air-liners ordered by Trans-Canada Air Lines has recently been delivered by its constructors, Vickers-Armstrongs Limited, Weybridge, Surrey. The Trans-Canada Viscounts, Mark 724, differ in many respects from those already in service with British European Airways, Air France, and Air Lingus. It is the first Viscount to be powered by the Dart 506, which gives an increase in climbing and cruising power of 80-90 shaft horse-power, with a 9 per cent. reduction in specific fuel consumption as compared with the Dart 505 engines in the earlier Viscounts. The extra power gives the Viscount 724 an increase of 18 m.p.h. in cruising speed, raising it to an average of 320 m.p.h.

Cabin accommodation provides seating for 48 passengers in 12 rows of four-abreast seats. A flight crew of two and two hostesses are carried. There are two toilets at the forward end of the passenger cabin, and a galley aft. Of the 20 oval " panoramic " windows, 14 are fixed and 6 are escape hatches.

The fuel system, with a capacity of 1,950 Imperial gallons, is designed for the use either of kerosene or of J.P.4 fuel. It is a four-tank system, using flexible bag-type tanks providing a separate feed to each engine. The aircraft has a hydraulically-operated nose-wheel. The undercarriage wheels are fitted with Dunlop brake assemblies incorporating Maxaret " non-skid " units. The Smiths autopilot, standard in other Viscounts, has been deleted from the T.C.A. aircraft, but provision has been made for the equipment to be installed if required.

The cockpit windshield is composed of five panels. The three centre panels are electrically-heated N.E.S.A. glass, provided with a fluid spray for de-icing in severe icing conditions. Each panel is fitted with a wind-screen wiper. The two side panels are tempered glass with vinyl interlayer, each incorporating a direct-vision panel.

Air conditioning to the passenger cabin is supplied from a flush air intake on the underside of the fuselage, through three engine-driven Roots-type blowers used in conjunction with choke valves, intercoolers and air-cycle refrigerators. A cabin air-recirculating system is fitted, which includes a Janitrol combustion heater for raising the cabin temperature both on the ground and in the air in the severe winter conditions of Canadian operation. This will maintain temperatures in the cabin and cockpit at 65 deg. F. in an outside temperature of −50 deg. F. at an altitude above 20,000 ft. In addition, there is an air-cycle refrigerator to prevent the cabin and cockpit temperatures from exceeding 80 deg. F. in sub-tropical climates. Cabin pressurisation, up to a maximum of 6·5 lb. per square inch, is regulated by an " AiResearch " controller which provides a range of cabin altitude selection from 0 to 8,000 ft. The rate of change of cabin pressure may also be selected over a range of 100-1,000 ft. per minute. Cabin pressure control is automatic and self-regulating during the climb to operating altitude.

De-icing of the wings and tail unit is by a thermal system, using heat exchangers and the engine exhaust gas to provide heat. The complete thermal system has been fully proved by flights in the ice-forming conditions of the Canadian winter.

In general, the Viscount 724 for T.C.A. has been to a large extent specially tailored for the needs of a North American operator. The aircraft has been extensively converted to use much American flight instrumentation and radio, and the cockpit has been widely re-designed in detail to conform to trans-Atlantic practice.

* * *

ELAND GAS TURBINES FOR ROTODYNE HELICOPTER

Shown in the illustration below is the Eland gas-turbine engine specially developed for the Fairey Rotodyne helicopter by D. Napier and Son, Limited, Acton, London, W.3. The Rotodyne, it may be recalled, is under construction by the Fairey Aviation Company Limited, and will have a payload of 11,000 lb. and a cabin capacity of 3,300 cub. ft. It has a fixed wing of 47-ft. span and a 90-ft. diameter four-bladed rotor reaction-driven by Fairey pressure-jet units mounted at the blade tips. Power is supplied by two Eland propeller turbines of the type illustrated, rated at 3,000 effective horse-power each.

In these engines an auxiliary compressor for supplying compressed air to the rotor is mounted co-axially at the rear of the engine and is supported by a tubular mounting which itself acts as the main engine mounting. Between the turbine and the auxiliary compressor is a hydraulic coupling arranged so that power can either be taken through the propeller for forward flight or through the auxiliary compressor to the rotor for vertical flight.

Forward of the turbine the engine is identical with the standard Eland engine, which has already accumulated many hours of running on the bench and in the Varsity flying test-bed. The standard Eland was described on page 121 of our issue of July 23.

* * *

RADIO VALVE ASSEMBLY BY INDUCTION HEATING

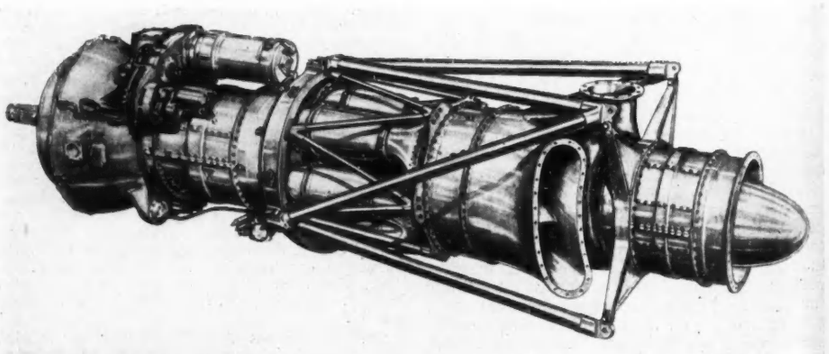
High-frequency induction heating lends itself to small brazing or soldering operations because the area heated can be strictly confined. In addition, the operation can be carried out in a controlled atmosphere, avoiding the need for fluxes. In view of these advantages, the process has been introduced into the manufacture of radio valves at the Springvale works of the M-O Valve Company, Limited. The equipment used is a 25-kW set made by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, who are the parent firm.

Operating at a frequency of 2 megacycles, several brazing operations are carried out during the valve assembly by using a series of interchangeable heating coils. An eutectic-alloy solder with a melting point of 778 deg. C. is used and the joints made include copper to copper, copper to copper-plated molybdenum, and copper to copper-plated mild steel. Copper and copper-plated mild steel are also joined to Nilo-K, an alloy with expansion characteristics which match those of glass.

* * *

LUBRICATION AT A DISTANCE

A lubricator which can be used on any standard size grease keg and incorporates a 10-ft. long rubber hose has been produced by Ch. J. Neuman Limited, South Croydon, Surrey. The lubricator consists of two main parts, a lid with the main pump, and a reinforced-rubber hose with a greasing head and " booster " at the far end. The lid is fastened to any standard size grease keg of 28 lb. or 40 lb. capacity by three adjustable clips; the pump unit incorporated in the lid is so constructed that one single stroke fills the rubber hose. The pressure exerted at the greasing head is 7,500 lb. per square inch, and once the hose has been filled the operator can grease 30 to 40 points using the booster.



Eland gas turbine. Two Eland propeller turbines supply power for the Fairey Rotodyne helicopter. A hydraulic coupling enables power to be transmitted to the propeller for forward flight, or alternatively to the rotor.

INSPECTING GAS TURBINE COMPONENTS

NON-DESTRUCTIVE TECHNIQUES WANTED

The need for new methods of testing aircraft gas turbines non-destructively was discussed recently in a lecture entitled "Non-Destructive Testing as Applied to Gas Turbine Aero Engines." given before the Non-Destructive Testing Group of the Institute of Physics by Mr. W. G. Cook, of the process-development department, Rolls-Royce, Limited. We give below extracts from the later part of his paper, in which he discussed techniques under investigation, in particular penetrant techniques, and outlined some of the inspection problems which still require to be solved. In the earlier part of the paper he summarised the various techniques in use at Rolls-Royce Limited—magnetic crack detection, magnetic permeability tests, chemical etching, electro-etching and electro-polishing techniques, anodising, X-ray techniques, and functional performance rig tests.

In inspecting gas turbine components, the use of gamma rays in place of X-ray does not seem to offer advantages, principally because of the thin sections and materials involved. Alpha-ray thickness measurements applied to the continuous production of thin sheet material does not yet seem capable of revealing localised defects in thin-walled castings of awkward shape. Beta rays, however, seem likely to prove effective in detecting internal defects in high-pressure rubber tubing. Ultrasonic testing methods, still being evaluated, have so far given exasperating results, usually due to awkward geometry, a situation unfortunately likely to get worse rather than better.

Magnetic induction, eddy-currents and resistance measurements are also affected by geometry and to date the difficulties have proved to be insuperable. For example, attempts are being made to detect cracks in the pin holes of compressor blades, but so far it has been found that the minute cracks which are the source of the trouble can give signals of a smaller order than such variables as surface condition, dimensional tolerances, etc. Much work has been done on resonance and damping methods, particularly on compressor blades, but so far no technique has been evolved suitable for production testing.

PENETRANTS

In addition to the old-established hot oil and chalk method, there is now a comparatively wide range of penetrants employing dye or fluorescent chemicals. Comparison of these penetrants presents a complicated problem. The application of different penetrants to the same batch of cracked specimens provides very doubtful evidence, since the first penetrant applied may or may not influence any subsequent test, and the cleaning of a crack fine enough to require a searching test is a dubious matter. The results of such tests are often confusing. Some penetrants also raise problems of interpretation and spurious indications in varying degrees.

Rolls-Royce Limited have been endeavouring to establish the physical properties of an ideal penetrant, a problem on which there appears to be little direct evidence. On a first approach it would appear that high capillarity, combined with low viscosity, is a prime factor. However, tests with glass capillaries rate most penetrants as fairly low in surface energy, whilst practical tests in water and aqueous solutions of high surface energy show that they are poorly adapted for crack detection.

On the other hand, most good penetrants have good spreading power and perhaps this is a more important criterion. The mechanisms of spreading are varied and intriguing, but their significance is not clear. In one experiment on capillary rise with a proprietary penetrant, the tube was left for some hours and the liquid eventually climbed higher up the outside of the tube than it did inside. Similarly, a mixture of paraffin and lard oil, which is a reasonably good penetrant, will climb over 2-in. vertically up a polished aluminium surface. These simple phenomena must have been seen by many, but it has not yet been possible to find any account of the physics involved or (what is more important) its significance as applied to crack detection. The author feels sure that a more exact knowledge of the physical processes would point the way to the development of better penetrants.

PROBLEMS FOR SOLUTION

Finally, it is desirable to state the inspection problems to be solved. In every case a method is required, which gives a quick and positive indication, is of a high standard of reproducibility, and is without complicated problems of interpretation and diagnosis.

Ideally, it is desired to cover inspection in the factory, in the repair units, and in service and field units, both in military and civil applications, where conditions call for robust and simple equipment. The methods should be capable of being worked by semi-skilled labour, since in the event of a national emergency the vastly increased range of technical activities represents a serious diffusion of technical manpower. Thus simple, foolproof techniques are needed for:—

1. *Inspection for surface and internal defects.*—That is of non-magnetic castings of thin section and complex shape, especially in the as-cast condition (primarily fairly large aluminium-alloy and magnesium-alloy castings). At present such castings have to be fettled and a top-surface layer removed all over before inspecting for defects. This top-surface layer is conventionally removed by dressing, but it is possible to smear cracks over in this process so that they are only found at a much later stage in manufacture. To overcome this trouble, in the case of aluminium castings caustic etching has been used, particularly for stressed components. This etching removes the surface layer and shows up cracks and defects very effectively, as shown in the accompanying illustration. Needless to say, it requires close control and in some alloys produces undesirable localised surface attack. Further, it cannot be applied to machined or part-machined castings. For magnesium castings no etching technique is employed. The castings are also X-rayed.

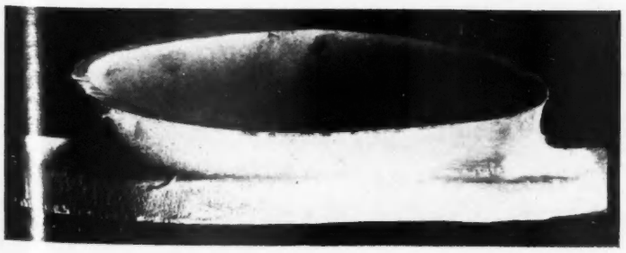
2. *Inspection of forged components.*—Such as compressor blades, turbine blades, discs, etc., in which defects are usually forged so tightly that all known penetrants fail to give any indication. Surface defects in non-magnetic members are detected by electro-polishing or etching and visual inspection. A more objective method of inspection is highly desirable, and in any case the problem of internal defects liable to cause fatigue failure remains a serious difficulty.

3. *The inspection of welded joints.*—Resulting from the rising temperatures and stresses due to the higher compression ratios and higher loadings at supersonic speeds, fabricated steel structures are replacing aluminium-alloy castings at the hot end of the compressor. The problem of inspecting effectively many feet of welded joints on annular components is formidable. In the case of stressed members it is undesirable to dress the welds, so a simplified geometry is not possible.

4. *The inspection of brazed joints.*—The difficulties of inspecting complicated brazed joints precludes the use of brazing in many cases. A reliable testing technique to assess the surface adhesion and adequate filling of the joint would lead to its more extensive use and solve many problems.

5. *The inspection of high-pressure metal-screened rubber tubing.* A technique simpler than the B-ray method mentioned earlier and readily applicable to engines in the field and at repair units is very desirable.

An examination of the work done by scientific workers in other apparently unrelated fields, such as dyeing, lubrication, forensic and medical science, etc., may throw light on some of these problems.



Aluminium alloy casting, with top surface removed partly by dressing and partly by caustic etching.

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THE HUMAN TOUCH IN INDUSTRY

Plans for 1956 Conference

Preliminary arrangements for a conference at Oxford in July, 1956, on human problems of industrial communities in the British Commonwealth and Empire, were made at a meeting of trade union officials and industrialists, under the presidency of H.R.H. the Duke of Edinburgh, at Buckingham Palace in July last. Substantial further progress was made at a second meeting at the Palace, also with the Duke of Edinburgh in the chair, on December 16, when those present decided to form themselves into an independent body for the purpose of organising the conference, and to accept responsibility for its policy and financial arrangements.

A main object of the gathering will be to bring together men and women from all parts of the Commonwealth with experience of the technical, managerial, and operative functions in industrial enterprises. The conference will be concerned principally with those human factors in industry which are not included within the ordinary scope of collective-bargaining arrangements, such as work satisfaction, welfare schemes, health hazards, and the many social problems which modern industrialisation creates for the individual, the family, and the community as a whole.

Care will be taken to preserve the independent character of the conference and, with this aim in view, it is not intended to invite overseas Governments to be directly represented. The meeting will be opened with an address by the Duke of Edinburgh, and it has been decided that there shall be a total of 280 delegates, of both sexes, between the broad age limits of 25 and 45; of whom about 190 will be invited from overseas areas and about 90 from representative centres in the United Kingdom.

The Duke of Edinburgh, K.G., has accepted the office of President of the conference, Sir Harold Hartley, F.R.S., has been appointed chairman of the newly-established organising council, and Sir John Hanbury-Williams has been made its honorary treasurer.

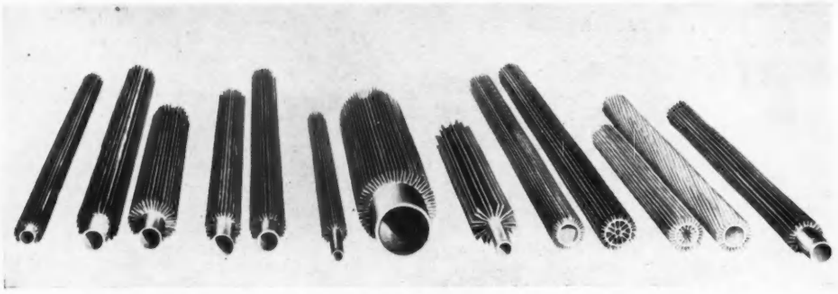


Fig. 1 The Brown Fintube is equipped with longitudinal fins and enclosed in an outer shell to form a heat exchanger. Several different types of Fintube are illustrated here.

EXTENDED-SURFACE HEAT EXCHANGERS

UNIT CONSTRUCTION SIMPLIFIES RE-ARRANGEMENT

The use of extended-surface tubes is the accepted means of keeping the size of a heat exchanger within reasonable limits. The surface of a tube can be extended in various ways to provide a greater area of contact for heat transfer, and the advantages of using such tubes are well known. The "Fintube," which has been developed in America by Mr. John Brown, is an extended-surface tube of a new type, in which the fins are added to lie longitudinally on the outside of the tube wall. With such tubes the arrangement of a heat exchanger on contra-flow principles is simplified. They also provide such a large area that relatively short lengths of tube can be used for heavy duties. A simple arrangement of the tubes with outer shells enables heat exchangers to be designed on the unit principle, standard units being coupled together in any required number to give the capacity needed for a particular duty. Heat exchangers on the unit principle, incorporating the Fintube, are now being made in this country by Brown Fintube, Limited, a subsidiary company of Birwelco, Limited, Chester-street, Birmingham, 6.

LONGITUDINALLY-FINNED TUBE

The basic element of this heat-exchanger unit is a tube of suitable size and wall thickness, with fins running longitudinally and welded to the outside of the tube wall. In certain circumstances internally-finned tubes are used, but as these tubes are produced by extrusion, there are limitations imposed on their manufacture and use by the types of metal suitable for extrusion. In the case of steel tubes, bright-rolled steel strip is roll-formed into channels, which are then welded to the tubes to form the fins. An idea of the range of sizes and types of the tube is given in Fig. 1, while Fig. 2 shows a group of 9 in. diameter steel tubes, finned and ready for fitting into a heat exchanger.

To form a heat exchanger unit the finned tube is shrouded in a closely-fitting outer tube or shell, with simple metallic ring joint to form a seal. This arrangement provides a passage between the inner and outer tubes and through the fins for one fluid, and through the centre tube for the other. Any number of the units can be joined together by suitable manifolds to give the heat-exchange capacity required. In practice the units are manufactured in a standard range of sizes, there being four sizes of inner tube and four sizes of shell. These can be arranged in a total of ten standard combinations, and are available in lengths of 5, 10, 15, 20, and 30 ft. From this range it is possible to build up a heat exchanger for almost any requirements.

ARRANGEMENT OF UNITS

Taking the standard inner and outer tube units as a basis the heat exchanger can be built

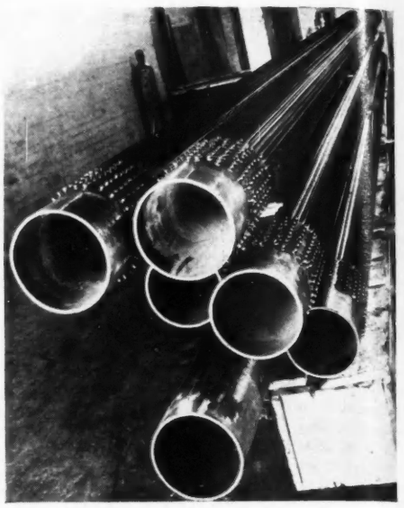


Fig. 2 A group of 9-in. diameter tubes, ready for fitting into shells.

up in various ways. A common arrangement is the "hairpin" assembly shown in Fig. 3, which illustrates a heat exchanger at an oil refinery. Tube units are joined by headers in U-form, and the complete heat exchanger is built up by connecting the required number of these "hairpin" assemblies together and providing connections for the entry and exit of the two fluids at opposite ends of the battery. It is obvious that any required capacity can be obtained by using a suitable number of units, and if at any time it should become necessary to alter the capacity, units can be added or removed without difficulty. A further advantage of the unit construction is that all the heat exchangers in a complete plant can be so designed that the units are of the same size, and the only difference between individual exchangers is in the number of units used. Maintenance is thus simplified, as it is only necessary to keep in stock a small number of spare inner elements, together with a few gaskets for sealing purposes, and perhaps a spare outer shell.

STORAGE TANK HEATING

A simple adaptation of the Fintube heat exchanger is also made for replacing the older form of coiled-tube heater for storage tanks. The disadvantage of the coiled-tube heater is

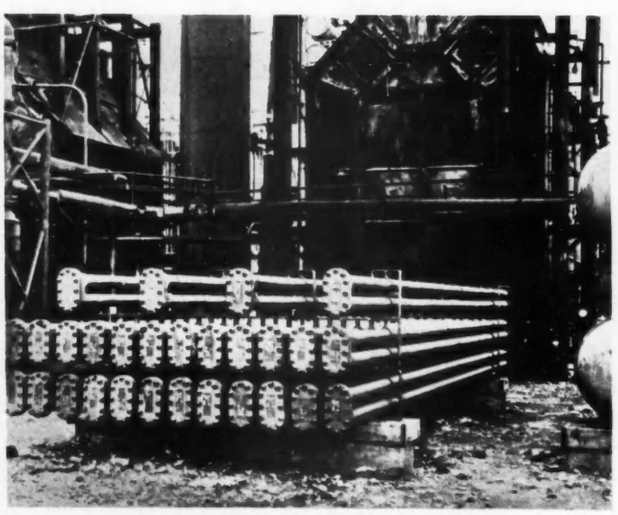


Fig. 3 Complete units arranged in "hairpin" form and coupled together as a heat exchanger.

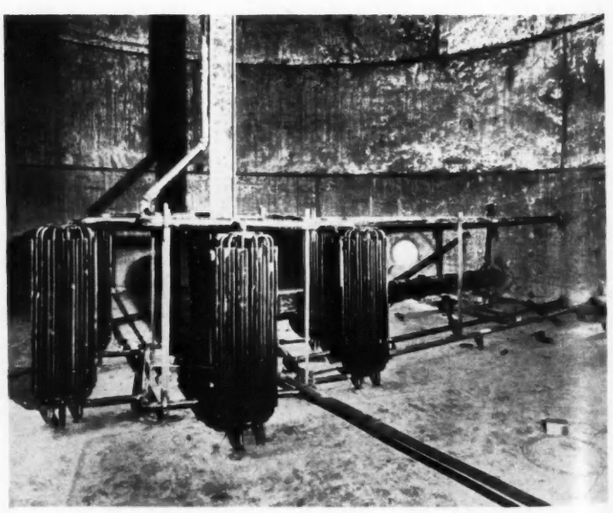


Fig. 4 Fintube inner elements grouped, without shells, as storage tank heaters.

that it is installed on the floor of the tank, where it is liable to become embedded in sludge and dirt. For tank heating, standard Fintubes without shells are arranged in groups of twenty, connected by suitable headers, and fitted with feet to stand on the floor of the tank in a vertical position. Any number of these heaters can be used, according to the heating requirements in the tank. They can be arranged in ring formation, as shown in Fig. 4, and will then impart a thermal flow to the tank contents. Similarly, groups of the tubes can be arranged in an open-ended tube of large bore for installation as tank suction heaters, which can be used in conjunction with, or independent of, vertical heaters as required. The heating medium in storage tank installations is usually steam, and the piping arrangements are of very simple form.

The Fintube units are manufactured as standard for pressures up to 600 lb. per square inch, but units can be supplied for higher pressures when necessary. Heat exchangers are in service with pressures of over 10,000 lb. per square inch, and with temperatures of 1,000 deg. F. Special materials can be used for making the tubes and shells when required for hygienic purposes, or to resist the corrosive action of particular fluids.

* * *

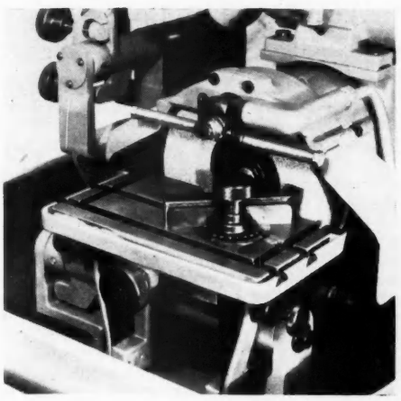
GRINDING AND LAPPING

Two-speed Independent-spindle Machine

The A.J.F. grinding and lapping machine, which is made in Switzerland, is available in Great Britain through the sole selling agents, A. A. Jones and Shipman, Limited, Narborough-road South, Leicester. The machine is made in two sizes, with 8-in. and 13½-in. diameter grinding wheels, respectively, the basic design being the same in both models. There are two grinding wheels, one for rough grinding and one for finish grinding, at opposite ends of a common spindle, and driven by the same 1·5-h.p. electric motor at 1,500 r.p.m.

An angularly-adjustable tool-support table is mounted in front of each wheel, and scales graduated in degrees are provided to enable the correct angle to be set. The tables are dove-tail slotted for a mitre-block, which is radially-

There are two spindles on the A.J.F. grinding and lapping machine, the lower one carrying roughing and finishing grinding wheels while the upper has a lapping wheel at the front and, if required, a diamond-impregnated wheel at the rear for grinding chip-breaker grooves.



An angularly-adjustable table and a mitre-block enable the correct angles to be set, and the table can be reciprocated across the wheel face on spring-steel supports by light hand pressure.

adjustable and is also equipped with a scale marked in degrees. Vertical spring-steel plates are used to support the tables, which can thus be oscillated rapidly across the grinding-wheel face by light hand pressure, while the tool is held in place against the mitre-block. The maximum available grinding area of the wheel is therefore used, and a fine finish is given to the tool. A reversing switch is provided for the driving motor, so that the grinding wheels can be rotated in either direction to suit right-hand or left-hand tools. Similarly, coolant, which is circulated from a sump in the machine column by a 0·4-h.p. motor and pump, can be directed to either face of the wheels.

For lapping there is a second spindle, mounted over the main grinding spindle and at right angles to it. The front end of the lapping spindle, which is independently driven by a 0·5-h.p. motor at 3,000 r.p.m., carries a lapping wheel 6 in. in diameter, recessed 3 in. on one side to give a lapping face of 1½ in. A tilting table and mitre-block, similar to those used with the grinding spindle, are provided, and the lapping spindle is reversible to suit tools of either hand.

The other end of the lapping spindle can be used as a second lapping station or, if required, extra equipment can be fitted for grinding chip-breaker grooves. In this case the spindle carries at the rear end a diamond-impregnated wheel 4¾ in. in diameter and $\frac{1}{4}$ to $\frac{3}{16}$ in. wide, according to requirements. To accommodate the tool there is a compound table, universally adjustable for direction and height, which can be reciprocated across the wheel by a hand lever.

* * *

SCHOOL OF AERONAUTICS AT BELFAST

It was announced at the annual meeting of the Senate of Queen's University, Belfast, by the Vice-Chancellor, Dr. Eric Ashby, that Short Brothers and Harland, Limited, Belfast, have made an offer of financial assistance to enable the University to establish a school of aeronautics. The firm has offered £7,000 towards the capital cost of equipping the proposed school and £4,000 a year towards the annual cost until such times as the University Grants Committee recommends that it should be borne by the recurrent Parliamentary grant.

The school will be located in one of the wings of the Engineering and Science Building now being erected. Its laboratory facilities will be made available not only to University students but also to students of the Belfast College of Technology. The Vice-Chancellor states that the endowment is sufficient to create a Chair of Aeronautics at Queen's.

DRYING VARNISH RAPIDLY

Infra-red plant at Printing Works

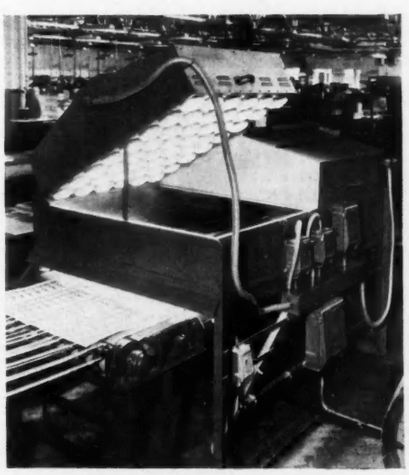
The glitter of gaily-coloured labels is enhanced and protected against damage or deterioration by a coating of transparent varnish. Drying this coating by natural means in a large label-printing works would require a huge space for storage and entail a considerable amount of labour. However, at the Co-operative Wholesale Society's printing works at Reading, where some hundreds of thousands of labels are printed every week for products ranging from tins of paint to bars of chocolate and packets of tea, the labels are dried ready for stacking within a few seconds of leaving the varnish coating-machine by an infra-red plant. The plant, only 6 ft. in length, was designed by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2.

The labels, which are printed in sheets up to 45 in. by 30 in. in size, are fed by hand into the varnish-coating machine and emerge on to a tape conveyor which carries them through the heating plant at speeds of up to 70 feet a minute. Inside the plant the varnished sheets are subjected to radiation from a horizontal bank of Osram infra-red reflector lamps mounted in reflector units and supported on a floor-mounting stand. To prevent radiation losses the sides of the plant are enclosed as far as possible with reflector sheeting. The bank of lamps can be raised from the working position in two sections to allow access for inspection and maintenance, as illustrated below.

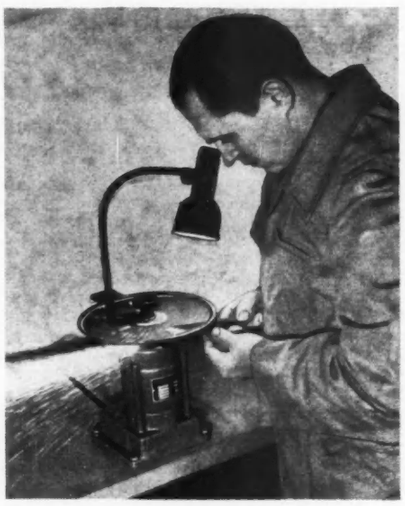
Besides varnished labels, book covers made from board up to 0·03 in. thick are dried in the plant. Drying times are similar to those for the labels and vary between 5 and 7 seconds according to the thickness of varnish. Output of label sheets or book covers ranges from 1,000 to 1,800 an hour.

Infra-red heating is also used to dry water-gum coatings on paper sheets used for receipt forms. Two identical G.E.C. lamp plants similar to the one employed for drying varnish are used for this. Each of these plants has its own tape conveyor and gum-spreading machine. The paper is prepared in sizes up to 21 in. by 16¾ in. and gum is applied in ½-in. wide strips along its length. The drying is accomplished in approximately five seconds and output from each unit is about 1,000 sheets an hour, the heating plants easily coping with the maximum output from the gum-spreading machines.

A distinct advantage in using lamp plant for drying coatings on paper is the reduction of the fire risk which would be present if sheathed wire-element plant were used.



Varnished or gummed labels are carried by tape-conveyors under the infra-red lamps which dry the coating in about 6 seconds.



The face of a tool being ground on the " visible-grinder " can be seen through the slots in the grinding wheel.

HAND GRINDING WITH TOOL FACE ALWAYS VISIBLE

The " visible-grinder " made by Stephan Frankfort, Germany, and marketed by Power Tools (Birmingham), Limited, Henley Street, Birmingham, 11, has a slotted grinding disc which enables the working face of a tool to be seen while it is actually being ground. The grinder consists of a vertical-spindle electric motor mounted on a cast-iron base, and carrying the grinding disc in the horizontal plane on top of the motor spindle. There are six narrow radial slots in the disc, and as it rotates at the normal working speed of approximately 2,900 r.p.m., the face of a tool being ground against the under side of the disc is clearly visible to the operator through the slots.

The grinding disc, 8¼ inches in diameter, is of steel, with the abrasive grit bonded on to both surfaces. A knurled nut with a left-hand thread and a rubber washer are used to clamp the disc against a shoulder on the motor spindle, and discs can be changed in a few seconds. Discs can be supplied with grit of different grades on the two surfaces, and to use a different grade it is then only necessary to turn the disc over. A wide range of grits is available, to suit cast iron, steel, non-ferrous metals, wood, plastics, rubber, glass and leather. Diamond-impregnated discs for use with tungsten-carbide tipped tools are in preparation. Worn discs can be re-faced with abrasive material.

The grinder has the advantage that only a very simple ring-guard is necessary, and as the disc is not shrouded, the whole of the grinding face on each side is available. " Lo-Volt " lighting is incorporated as standard, a 15-watt lamp and shade being mounted over the grinding disc.

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ORPHEUS TURBO-JET BENCH TRIALS

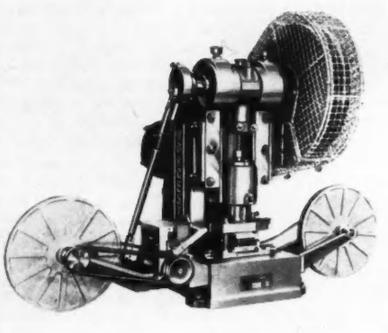
The Bristol Aeroplane Company, Limited, Filton House, Bristol, have commenced running trials on the Orpheus jet engine which is being developed for the Folland Gnat light-weight fighter aircraft. The company state that the measured weight of the Orpheus, which has been designed specially for applications requiring a medium-thrust light-weight engine, is an improvement on the first design estimates. Detail design of the Orpheus commenced about a year ago, and during the last 12 months all the main components have been subjected to rig testing.

AUTOMATIC FEED ON BENCH POWER PRESSES

The " Worcester " range of bench power presses, made by Jones and Attwood, Limited, Stourbridge, Worcestershire, is now available with automatic feed. It can be fitted to new presses, which are made in 2, 3, and 6-ton capacities, or it can be supplied for fitting to existing presses.

The basic component of the automatic feed is a twin-roll unit, capable of taking stock up to 4 in. wide, and having an infinitely-variable adjustment giving feeds up to 1¼ in. The rolls are of hardened steel, knurled or plain as required, and the top roll is spring loaded to provide the necessary traction pressure on the stock. The drive is taken from an adjustable disc-crank at the end of the press crankshaft, through a connecting rod and a roller ratchet to the lower roll. A lever-operated lifting device is provided to lift the top roll clear of the stock when required. This can be used by hand for initial stock-threading, or it can be operated by the press ram when it is near the bottom of its stroke, to permit of stock-positioning by the tools.

The feed rolls are normally arranged to pull the stock through the press. As optional extra equipment a stock-coil holder and a scrap re-winder can be provided, the latter being driven by a V-belt from the lower feed roll. By means of extra gears in the feed, roll drive, the feed can be increased to a maximum of 3½ in. Other modifications can be made to meet special requirements.



The automatic feed on the " Worcester " range of bench power presses has an infinitely-variable feed up to 1¼ in. and will take stock up to 4 in. wide.

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PLASTICS PIPELINES FOR COLD PLUMBING

Corrosion-Resistant and Flexible

A range of plastics pipelines, known as Shirene, for domestic or industrial plumbing and for all cold-liquid conveyance, has been introduced by Shires and Company (London), Limited, Guiseley, Yorkshire, and is available in all standard sizes up to 12 in. in diameter and lengths up to 500 ft. in multiples of 50 ft. Shirene piping will resist high pressures including the expansion of water into ice, and is immune to corrosion by acids, alkalis, salt water and chemical solutions.

The new tubing is supplied in two alternative gauges—normal and heavy. Standard screwed and compression joints may be used with the latter, but the normal gauge cannot be threaded and compression sleeve jointing is, therefore, recommended. Alternatively, both gauges can be easily butt-welded by softening the ends by radiant heat and pressing them together.

Such a combination of mechanical and chemical properties render Shirene pipelines particularly suitable for many plumbing duties

Shirene plastics pipeline can be easily butt-welded by softening the ends by radiant heat and pressing them together.

where the risk of frost damage is great; for handling corrosive fluids of all types in industry and for piping consumable liquids like beer, milk, vinegar and soft drinks where any risk of contamination must be avoided.

A wide range of applications can be met in agriculture in distributing water to outbuildings, cattle troughs, and so on. Mole ploughing has proved a very efficient method of laying Shirene tube, speeds of over 200 ft. per minute having been achieved.

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HYDRO-ELECTRIC WORK IN SCOTLAND

The North of Scotland Hydro-Electric Board have published details of their Gisla scheme in the Island of Lewis, which is known as Constructional Scheme No. 34. It provides for harnessing the waters of the Gisla River, which flows out of Loch Grunnabhat on the west coast of Lewis and has a catchment area of about 5 sq. miles. A further 2 square miles of an adjacent area will also be utilised. The civil engineering work will include a dam 300 ft. long with a maximum height of 27 ft., which will be built across the river. Water will be led thence by a pipe-line 2,700 ft. long to a power station with a capacity of 600 kW at the confluence of the river and Little Loch Roag.

It is also announced that the first of the two 7·7-MW turbo-alternators in the Torr Achilty station of the North of Scotland Hydro-Electric Board was started on Saturday, December 11. As described on page 630, *ante*, this station forms part of the Conon Valley scheme.

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MINIATURE PENTODE VALVE WITH VERY CLOSE GRID SPACING

A miniature pentode valve with the high mutual conductance of 16·5 milliamperes per volt has been introduced by Mullard, Limited, Century House, Shaftesbury-avenue, London, W.C.2. It has a slope to capacitance ratio of 1·7 to 1. The performance of this valve has been achieved by spacing the control grid wires at a distance of only 60 microns (approx 0·0024 in.) from the cathode. This has involved a new method of assembly, for the previous method in which the grid wires were wedged in notches in the support rods did not permit of sufficiently exact location. In the new method, the grid wires are wound under tension around the support wires in the form of a long helix and are anchored in position by glass-cement. This method enables fine grid wire to be used and close tolerances maintained.

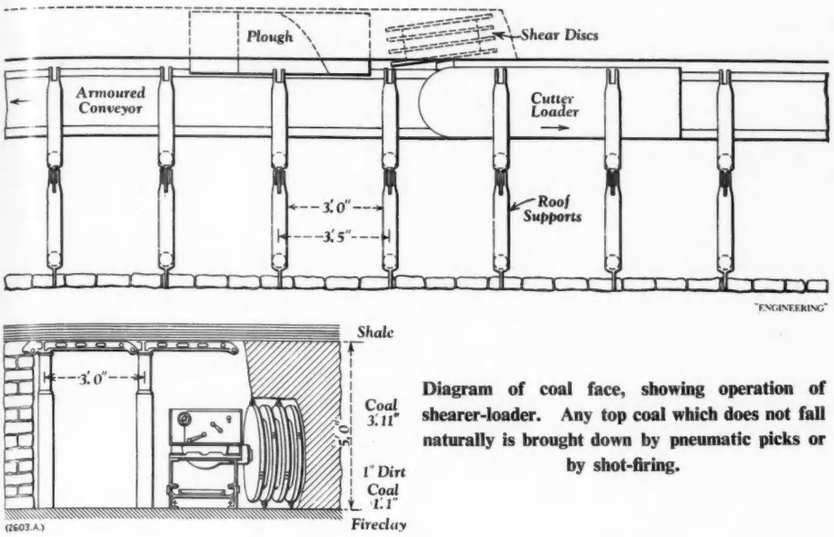


Diagram of coal face, showing operation of shearer-loader. Any top coal which does not fall naturally is brought down by pneumatic picks or by shot-firing.

COAL CUTTING AND LOADING IN ONE OPERATION

THE ANDERTON SHEARER-LOADER

The logical development from the mechanical coal cutter was the cutter-loader, which not only cuts the coal from the seam but also loads it on to a conveyor for the first stage of its journey to the surface. Such a development was attended by many difficulties, but several different types of machine have been evolved and are in successful use. No single cutter-loader is suitable for all applications, however, as conditions vary greatly in different mines. The latest machine to be developed for carrying out both operations is the Anderton shearer-loader, which has been tried under difficult conditions by the National Coal Board. Experience has shown that it is suitable for use under a relatively poor roof, and that it is independent of any natural floor parting. The Anderton machine is an adaptation of a standard chain-type coal cutter, and arrangements have been made with the various patentees for each British coal-cutter manufacturer to supply the necessary conversion parts for his own machine. Conversion parts can also be made in the N.C.B. mechanical workshops. The number of Anderton shearer-loaders in use in various N.C.B. Divisions at the end of 1954, was approximately fifty. The machine has been described in N.C.B. Information Bulletin No. 54/129.

SHEARING DISCS ON COAL CUTTER BODY

The Anderton shearer-loader is based on a standard coal cutter from which the cutting-chain assembly has been removed. In its place is mounted a special gear box which carries a horizontal shaft projecting towards the coal face. This shaft lags at an angle of 7½ deg. to a line at right angles with the centre-line of the machine, and carries a number of shearing discs for cutting the coal. The number of discs varies according to the hardness of the coal and the depth of cut required. Each of the discs carries at its periphery a number of cutter-pick boxes, varying according to the nature of the coal seam between four and eight but usually being six, in which special tungsten-carbide tipped cutter-picks are mounted. The cutting diameter, over the tips of the picks, is at present 36 in. or 40 in. At a speed of 71 r.p.m., a pick speed of 740 ft. per minute is obtained when using a 40 in. disc. Cuts of 16 to 22 in. deep have been made successfully. Deeper cuts have been tried, but 2 in. is so far about the maximum, as above this dimension there is a danger of upsetting the balance of the machine.

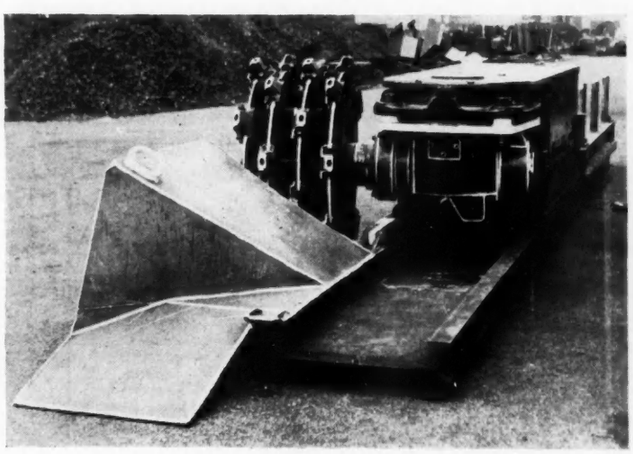
The shearer-loader has a Clifton-wheel haulage which draws it along on top of an armoured flexible conveyor, on which it is mounted by means of a specially-designed underframe. This frame raises the machine so that the discs cut to floor level. A double-ended fabricated steel plough is attached to the rear end of the machine by a rigid coupling. This plough deflects the coal to the conveyor during the cutting run. When the machine has reached the end of the coal face, it is reversed, and the opposite side of the plough loads all the loose coal left in the track of the machine. Water sprays for dust-suppression are incorporated in the plough, the water being directed to the tops of the shearing discs.

SIMPLICITY OF OPERATION

The operation of the machine can be started and finished at any point along the length of the coal face, and the actual length of face is not critical. Up to the present the maximum length of face cut has been about 150 yards, but this figure has been controlled by other factors. It is necessary to cut two stable-holes in the face to accommodate the machine. The stable-holes are usually 6 yards long at the tail-gate end to accommodate the rear conveyor drive, the dead length of the machine and cable-carrier; and 10 yards long at the loader-gate end to allow for the forward drive unit, plough and main gate.

In operation, the haulage rope is connected and tensioned, and with the shearing discs revolving to cut upwards into the coal, the machine is drawn along the coal face to make the first cut. A large proportion of the coal cut is thrown over the shearing discs and deflected by the plough on to the conveyor. Any top coal which does not fall naturally is brought down by pneumatic picks or by shot-firing, according to circumstances. When the machine reaches the tail-gate at the end of the face, the haulage is reversed and, with the discs in neutral the machine is run back along the face to the starting point. Any coal which was left on the track during the cutting run is then loaded on to the conveyor by the opposite side of the plough. While this run is being made, the conveyor is "snaked" up to the face behind the shearer-loader, temporary roof props being set as the work proceeds. On arrival back at the loader-gate stable-hole, the loader and conveyor drive-head are jacked over to the face, and the machine is then ready to make a second cut.

Speeds of 7 to 9 ft. a minute have been reached during cutting. When the machine is on the return run, and is only ploughing, the speed is governed only by the rate at which the conveyor can remove the coal, and by the speed of cable handling. Faces 160 yards long have been ploughed back in ten minutes. The complete operation of loading, ploughing back and moving over can be completed on a face 150 yards long in less than two hours under normal conditions. A team of twelve men is required for operation of the machine. Of these twelve, four are engaged on forming the stable-holes, two work the machine and six are employed to "snake" the conveyor and set roof supports.



The Anderton shearer-loader is an adaptation of a standard coal cutter. Coal is cut by a number of discs and lifted on to a conveyor by a plough.

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HYDRO-ELECTRIC POWER FOR UGANDA

Film of Owen Falls Dam

The Owen Falls Dam and the story of its construction were the subject of a colour film, called "Power for Uganda," presented on Thursday, December 16, at the National Film Theatre, Waterloo. The film, made by Gateway Film Productions, Limited, 470 Green-lanes, London, N.13, for the Uganda Electricity Board and the consultants and contractors, illustrated the course of the work from the initial survey of the site to the opening by Her Majesty the Queen in April, 1954.

Both the construction work and the production of associated plant were covered in the film and diagrams were used to show the nature of the problems involved. The running time of the film is approximately 50 minutes. A number of articles on the Owen Falls scheme have appeared in ENGINEERING (vol. 177, pages 290, 497, 528 and 579, 1954).

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. An asterisk(*) indicates events appearing in the list for the first time. Particulars of forthcoming exhibitions and conferences not included below may have appeared in ENGINEERING, *November 26, page 710. Organisers are invited to send to the Editor particulars of forthcoming events as soon as arrangements are made.*

HIGHWAY RESEARCH BOARD, NATIONAL MEETING.—Tues., Jan. 11, to Fri., Jan. 14, at the National Academy of Sciences, Washington, D.C., U.S.A. Apply to the secretary of the Board, 2101 Constitution-avenue, Washington 25, D.C.

*PROBLEMS OF AIRCRAFT PRODUCTION.—Fri. and Sat., Jan. 14 and 15, at the University of Southampton. Organised by the Institution of Production Engineers, 10 Chesterfield-street, London, W.1. Tel. GROsvenor 5254. See ENGINEERING, December 10, 1954, page 751.

PACKAGING EXHIBITION, FOURTH INTERNATIONAL.—Tues., Jan. 18, to Fri., Jan. 28, at Olympia, London, W.14. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

STATIONERY TRADE FAIR.—Mon., Feb. 7, to Fri., Feb. 11, at Harrogate. Organised by the Stationers' Association of Great Britain and Ireland, 227 Strand, London, W.C.2. Tel. CENtral 7293.

BUSINESS EFFICIENCY EXHIBITION.—Tues., Feb. 8, to Fri., Feb. 11, at the Granby Hall, Leicester. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

AGRICULTURAL MACHINERY AND EQUIPMENT EXHIBITION (INTERNATIONAL).—Sun., Feb. 13, to Sun., Feb. 20, at the Palais du Centenaire, Brussels. Organised by the Société de Mecanique et d'Industries Agricoles S.A., 29 Rue de Spa, Brussels.

HARDWARE TRADES FAIR.—Mon., Feb. 14, to Fri., Feb. 18, at the Royal Horticultural Society's Halls, Vincent-square, London, S.W.1. Organised by Universal Exhibitions Ltd., 74 Holland Park, London, W.11. Tel. PARk 7360.

SCOTTISH NATIONAL HANDICRAFTS AND HOMECRAFTS EXHIBITION.—Thurs., Feb. 24, to Sat., Mar. 5, at the McLellan Galleries, Sauchiehall-street, Glasgow. Organisers: Henderson Exhibitions Ltd., 74 Holland Park, London, W.11. Tel. PARk 7360.

NICE INTERNATIONAL FAIR.—Sat., Feb. 26, to Mon., Mar. 14. Inquiries to the secretary, Foire de Nice, 5 Rue Hotel de Ville, Nice.

*LEIPZIG INTERNATIONAL FAIR.—Spring Fair: Sun., Feb. 27, to Wed., Mar. 9. Autumn Fair: Sun., Sept. 4, to Fri., Sept. 9. *Agents:* Willoughby and Young, 6a Smith-street, London, S.W.3. Tel. SLOane 1594.

STATIONERY AND BOOK TRADES FAIR.—Mon., Feb. 28, to Fri., Mar. 4, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Organised by National Newsagent Ltd., 149 Fleet-street, London, E.C.4. Tel. CITy 2604.

AGRICULTURAL MACHINERY EXPOSITION (INTERNATIONAL).—Tues., Mar. 1, to Sun., Mar. 6, at the Parc des Expositions, Porte de Versailles, Paris. Organised by the Union des Exposants de Machines et d'Outillage Agricoles, 95 Rue St. Lazare, Paris, 9e. *Agent:* Mr. R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

AIR POLLUTION CONGRESS (FIRST INTERNATIONAL).—Tues. and Wed., Mar. 1 and 2, at the Hotel Statler, New York. Organised by the Society of Mechanical Engineers, 29 West 39th-street, New York, U.S.A. See ENGINEERING, November 26, 1954, page 682.

IDEAL HOME EXHIBITION.—Tues., Mar. 1, to Sat., Mar. 26, at Olympia, London, W.14. Organised by Associated Newspapers, Ltd., New Carmelite House, London, E.C.4. Tel. CENtral 6000.

FRANKFURT INTERNATIONAL TRADE FAIR.—Sun., Mar. 6, to Thurs., Mar. 10. *Agents:* L.E.P. Transport, Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

*COLOGNE INTERNATIONAL SPRING FAIR.—Household Goods and Hardware: Sun., Mar. 6, to Tues, Mar. 8. Textiles and Clothing: Sun., Mar. 13, to Tues., Mar. 15. *Agent:* Mr. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

VIENNA INTERNATIONAL SPRING FAIR (36TH).—Sun., Mar. 13, to Sun., Mar. 20. *Agents:* The British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7476.

ASTE WESTERN INDUSTRIAL EXPOSITION.—Mon., Mar. 14, to Fri., Mar. 18, at Los Angeles, California. Organised by the American Society of Tool Engineers, 10700 Puritan-avenue, Detroit 38, Michigan, U.S.A.

(A.S.E.E.) ELECTRICAL ENGINEERS' EXHIBITION.—Tues., Mar. 15, to Sat., Mar. 19, at Earl's Court, London, S.W.5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. Apply to Mr. P. A. Thorogood, Electrical Engineers (A.S.E.E.) Exhibition, Ltd., 23 Bloomsbury-square, London, W.C.1. Tel. MUSeum 3450.

UTRECHT INTERNATIONAL SPRING FAIR.—Tues., Mar. 22, to Thurs., Mar. 31. *Agent:* Mr. W. Friedoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

COPENHAGEN INTERNATIONAL FAIR (9TH).—Fri., Mar. 25, to Sun, April 3, Technical Section. Fri., April 15, to Sun., April 24, Commercial Section. Organised by Dansk Udstillings Syndikat A/S, Forums Anneks Julius, Thomsens Plads, Copenhagen K, Denmark.

FACTORY EQUIPMENT EXHIBITION (THIRD).—Mon., Mar. 28, to Sat., April 2, at Earl's Court, London, S.W.5. Apply to Mr. J. E. Holdsworth, 117 Kingsway, London, W.C.2. Tel. CHAncery 2318.

PROTECTION OF STRUCTURAL STEEL.—Thurs., Mar. 31, and Fri., April 1, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Symposium organised by the Corrosion Group of the Society of Chemical Industry. Communications to Mr. S. C. Britton, Tin Research Institute, Fraser-road, Perivale, Middlesex. Tel. Perivale 4254. See ENGINEERING, November 26, 1954, page 682.

*MILAN INTERNATIONAL SAMPLES FAIR.—Tues., April 12, to Wed., April 27. *Agent:* Dr. V. Schiazzano, 652 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 5521.

*LYONS INTERNATIONAL TRADE FAIR.—Sat., April 16, to Mon., April 25. *Agents:* Robert Brandon and Partners, Ltd., 47 Albemarle-street, London, W.1. Tel. HYDe Park 0901.

SWISS INDUSTRIES FAIR.—Sat., April 16, to Tues., April 26, at Basle, Switzerland. Apply to the Swiss Legation, 18 Montague-place, Bryanston-square, London, W.1. Tel. PADdington 0701.

LIÉGE INTERNATIONAL TRADE FAIR.—Sat., April 23, to Sun., May 8, at Liége. Organised by the Foire Internationale de Liége, 17 Boulevard d'Avroy, Liége, Belgium. *Agents:* Mattis Industries, Ltd., 252 Abbey House, Victoria-street, London, S.W.1. Tel. ABBey 7571.

*BRUSSELS INTERNATIONAL TRADE FAIR.—Sat., April 23, to Sun., May 8, at the Palais du Centenaire, Brussels. Apply to the organisers at that address.

PHYSICAL SOCIETY'S EXHIBITION OF SCIENTIFIC INSTRUMENTS AND APPARATUS (39TH).—Mon., April 25, to Thurs., April 28, at the Royal Horticultural Hall, Vincent-square, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. Tel. KENsington 0048. See ENGINEERING, November 5, 1954, page 595.

BRITISH INDUSTRIES FAIR.—Mon., May 2, to Fri., May 13, at Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars from British Industries Fair Ltd., Ingersoll House, 9 Kingsway, London, W.C.2. Tel. COVent Garden 1461; or from the general manager, British Industries Fair, 95 New-street, Birmingham, 2. Tel. Midland 5021.

*DUBLIN SPRING SHOW AND INDUSTRIES FAIR.—Tues., May 3, to Sat., May 7, at Ballsbridge, Dublin. Apply to the Royal Dublin Society, Ballsbridge, Dublin.

*NORTHERN RADIO SHOW.—Wed., May 4, to Sat., May 14, at the City Hall, Manchester. Organised by the Radio Industry Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

*GERMAN HANDICRAFTS AND TRADE FAIR.—Fri., May 6, to Sun., May 15, at Munich. Organised by the Verein für Handwerks-Ausstellungen und Messen e.V., Theresienhöhe 14, Munich 12, Germany.

*PARIS TRADE FAIR (44TH).—Sat., May 14, to Mon., May 30. *Agent:* Mrs. M. Hyde-Joucla, 14 Rugby Chambers, Rugby-street, London, W.C.1. Tel. CHAncery 6794.

CANADIAN INTERNATIONAL TRADE FAIR (EIGHTH).—Mon., May 30, to Fri., June 10, at Toronto. Further information from Miss M. A. Armstrong, Canadian Government Exhibition Commission, Canada House, Trafalgar-square, London, S.W.1. Tel. WHItehall 8701.

WORLD PETROLEUM CONGRESS.—Mon., June 6, to Wed., June 15, in Rome. Apply to the British National Committee, 26 Portland-place, London, W.1. Tel. LANgham 2250.

*BUILDING PLANT EXHIBITION.—Wed., June 8, to Wed., June 15, at the Queenslie Industrial Estate, Glasgow. Organised by the Ministry of Works, Lambeth Bridge House, London, S.E.1. Tel. RELiance 7611. See ENGINEERING, December 10, 1954, page 773.

*NON-DESTRUCTIVE TESTING CONGRESS.—Wed., June 22, to Sat., June 25, at the Royal Technical College, Glasgow. Summer Meeting, Non-Destructive Testing Group, Institute of Physics, 47 Belgrave-square, London, S.W.1. Tel. SLOane 9806.

GREAT YORKSHIRE AGRICULTURAL SHOW.—Tues., July 12, to Thurs., July 14, at Harrogate, Yorkshire. Organised by the Yorkshire Agricultural Society, Cliftonfield, Shipton-road, York. Tel. York 3102.

*DRY CLEANING, DYEING AND ALLIED TRADES EXHIBITION.—Fri., July 15, to Sun., July 24, at the Ausstellungspark, Munich. Organised by the Internationale Fachausstellung Chemisch-Reinigung und Färberei, Geschäftsstelle, Munich 12, Germany.

INTERNATIONAL WATER SUPPLY EXHIBITION.—Mon., July 18, to Thurs., July 21, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Inquiries to Mr. L. Millis, O.B.E., International Water Supply Association, 34 Park-street, London, W.1. Tel. GROsvenor 1092.

*DUBLIN HORSE SHOW AND INDUSTRIAL FAIR.—Tues., Aug. 2, to Sat., Aug. 6, at Ballsbridge, Dublin. Organised by the Royal Dublin Society, Ballsbridge, Dublin.

*MOTOR INDUSTRY SUMMER SCHOOL.—Sat., Aug. 20, to Sat., Aug. 27, at Corpus Christi College, Cambridge. Organised by the Institute of the Motor Industry, 40 Queen's Gate, London, S.W.7. Tel. WEStern 0915. See ENGINEERING, December 10, 1954, page 772.

*NATIONAL RADIO SHOW.—Wed., Aug. 24, to Sat., Sept. 3, at Earl's Court, London, S.W.5. Organised by the Radio Industry Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

*PRESTRESSING, CONFERENCE ON.—Mon., Aug. 29, to Fri., Sept. 2, at the Royal Tropical Institute, Mauritskade 63, Amsterdam 0, Holland. Organised by the Fédération Internationale de la Précontrainte, Groningsestraat 15, The Hague. See ENGINEERING, December 17, 1954, page 782.

*INSTRUMENT EXHIBITION AND CONFERENCE (10TH ANNUAL).—Mon., Sept. 12, to Fri., Sept. 16, at the Shrine Exposition Hall, Los Angeles. Organised by the Instrument Society of America, 3443 South Hill-street, Los Angeles 7, California, U.S.A.

*GAS SALES AND SERVICE CONFERENCE (FOURTH).—Tues., Sept. 13, to Thurs., Sept. 15, at the Heads of Ayr Holiday Camp, Ayr, Scotland. Organised by the Gas Council, 1 Grosvenor-place, London, S.W.1. Tel. SLOane 4554.

*ELECTRICAL ENERGY CONGRESS.—Mon., Sept. 19, to Fri., Sept. 23, in London. Tenth congress of the International Union of Producers and Distributors of Electrical Energy (UNIPEDE). Apply to the Information Department, North of Scotland Hydro-Electric Board, 16 Rothesay-Terrace, Edinburgh, 3. Tel. Edinburgh Central 1361.

ALL-BRITISH TRADE FAIR.—Thurs., Sept. 29, to Sun., Oct. 16, in the Tivoli Gardens and the Forum, Copenhagen, Denmark. Inquiries to the British Overseas Fairs, Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711. See ENGINEERING, July 16, 1954, page 69.

GERMAN PLASTICS INDUSTRY.—Sat., Oct. 8, to Sun., Oct. 16, at Düsseldorf, Germany. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf. *Agents:* John E. Buck & Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

BUILDING EXHIBITION (26TH).—Wed., Nov. 16, to Wed., Nov. 30, at Olympia, London, W.14. Apply to the Building Trades Exhibition, 4 Vernon-place, London, W.C.1. Tel. CHAncery 2223.

*METAL-PHASE TRANSFORMATIONS, SYMPOSIUM.—In November. Apply to the Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 6233. See ENGINEERING, December 3, 1954, page 72[illegible].

NOTICES OF MEETINGS

Association of Bronze and Brass Founders

MANCHESTER
Discussion on "Sands for Non-Ferrous Foundries," opened by A. Tipper. Meeting arranged under the Association's advisory service scheme. Engineers' Club, Albert-square, Manchester. Mon., Jan. 10, 7.15 p.m.

British Institution of Radio Engineers

LIVERPOOL
"Some Interesting Applications of Electronics to Photography," by D. M. Neale. Merseyside Section. College of Technology, Byrom-street, Liverpool 3. Thurs., Jan. 6, 7 p.m.
MANCHESTER
Discussion on "Problems in the Design and Production of Car Radio," opened by C. L. Caiger. North-Western Section. College of Technology, Sackville-street, Manchester. Thurs., Jan. 6, 7 p.m.
NEWCASTLE-UPON-TYNE
Address by the President of the Institution, Rear-Admiral (L) Sir Philip Clarke. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Jan. 12, 6 p.m.

Chemical Engineering Group

LONDON
Symposium on "Refrigeration," introduced by Ezer Griffiths. "Volatiles," by J. C. Fidler; and "Some Thermodynamic Properties of Fish and Their Effect on Rate of Freezing," by R. A. K. Long. Geological Society, Burlington House, Piccadilly, W.1. Tues., Jan. 11, 5.30 p.m.

Illuminating Engineering Society

LONDON
"Fading and Related Effects Associated with Radiation from Light Sources," by B. S. Cooper. Royal Society of Arts, John Adam-street, W.C.2. Tues., Jan. 11, 6 p.m.
BRISTOL
"Studies in Interior Lighting," by J. M. Waldram. Bath and Bristol Centre. Royal Hotel, Bristol. Fri., Jan. 7, 6.15 p.m.
CARDIFF
"Studies in Interior Lighting," by J. M. Waldram. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Jan. 6, 5.45 p.m.
EDINBURGH
"Street-Lighting Lantern Design," by T. M. Christie. Edinburgh Centre. Manor Club, 12 Rothesay-place, Edinburgh 3. Wed., Jan. 5, 7 p.m.
GLASGOW
"High Bay Lighting," by F. Jones. Glasgow Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Jan. 6, 7.30 p.m.

Incorporated Plant Engineers

LONDON
"The Writing and Presentation of a Technical Report for a Non-Technical Board of Directors," by W. J. Dickie. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Jan. 4, 7 p.m.
BIRMINGHAM
"Gas Turbines in Industry," by J. R. Needham. Birmingham Branch. Imperial Hotel, Birmingham. Fri., Jan. 7, 7.30 p.m.
MANCHESTER
"Pulverised Coal Firing for Lancashire Boilers," by V. Taylor. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Jan. 11, 7.15 p.m.
PETERBOROUGH
Various short papers. Peterborough Branch. Campbell Hotel, Bridge-street, Peterborough. Thurs., Jan. 6, 7.30 p.m.
SOUTHAMPTON
"Industrial Instrumentation," by C. M. V. Benwell. Southampton Branch. Polygon Hotel, Southampton. Wed., Jan. 5, 7.30 p.m.

Institute of British Foundrymen

BRADFORD
"Metallurgical Aspects of Moulding," by H. Forrest. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., Jan. 8, 6.30 p.m.
BURNLEY
"Design and Gating of Various Castings," by W. Collinge. Burnley Section. Burnley Technical College, Ormerod-road, Burnley. Wed., Jan. 5, 7.30 p.m.
GLASGOW
"Production and the Foundry," by E. W. Barrell. Scottish Branch. Royal Technical College, Glasgow. Sat., Jan. 8, 3 p.m.
NEWCASTLE-UPON-TYNE
Open Meeting. Visit of John Bell, President of the Institute. Newcastle Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Sat., Jan 8, 6 p.m.
SHEFFIELD
"Britain's Largest Steel Casting," with film, by S. Taylor. Sheffield Branch. College of Technology, Pond-street, Sheffield. Mon., Jan. 3, 7.15 p.m.

Institute of Fuel

LONDON
"Integration in the Iron and Steel Industry," by W. F. Cartwright. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Jan 13, 5.30 p.m.
NEWCASTLE-UPON-TYNE
"Carbonisation of Blends of Coal to Produce Metallurgical Coke," by H. Bardgett. North-Eastern Section. King's College, Newcastle-upon-Tyne. Mon., Jan. 10, 6.30 p.m.

Institute of Metals

LONDON
"Some Aspects of Twinning and Kinking in Metals," by Professor A. H. Cottrell. London Local Section. Thurs., Jan 6, 6.30 p.m.
BIRMINGHAM
Debate: "That, at the Present Stage of Industrial Metallurgy, Empirical Methods of Research are More Profitable than those Employing the Fundamental Approach." Birmingham Local Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Jan. 6, 6.30 p.m.
OXFORD
"Titanium," by Major P. Litherland Teed. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Jan. 4, 7 p.m.
SWANSEA
"Oxidation of Metals," by Dr. U. R. Evans. South Wales Local Section. Metallurgy Department, University College, Singleton Park, Swansea. Wed., Jan. 5, 6.45 p.m.

Institute of Refrigeration

LONDON
"Ground and Airborne Equipment for Cooling Aircraft Cabins," by N. Anderson. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Tues., Jan. 4, 5.30 p.m.

Institute of Welding

LONDON
"To What Degree Are Engineering Structures Unsafe?" by A. H. Chilver. North London Branch. Manson House, 26 Portland-place, W.1. Thurs., Jan 6, 7.30 p.m.
MANCHESTER
"Welding Design: Theory and Practice," by F. Koenigsberger. Manchester Branch. College of Technology, Sackville-street, Manchester. Wed., Jan 5, 7.15 p.m.
MIDDLESBROUGH
"Welding in Shipbuilding," by D. Hardie. North-Eastern (Tees-Side) Branch. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Thurs., Jan. 6, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Detail Design of Welded Structures," by T. L. Usherwood. North-Eastern (Tyneside) Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Thurs., Jan. 6, 7 p.m.
PORTSMOUTH
"Some Troubles in Welding Ferrous Metals," by R. G. Burt. Portsmouth Branch. College of Technology, Portsmouth. Thurs., Jan. 6, 7 p.m.

Institution of Civil Engineers

LONDON
"Reconstruction of Deptford Creek Bridge," by F. M. Fuller and J. N. C. Couper. Works Division. Tues., Jan. 4, 5.30 p.m.
"The Requirements of a Civil Airport, as Typified by London Airport," by B. E. Willett. Airport Division. Tues., Jan. 11, 5.30 p.m.

Institution of Electrical Engineers

LONDON
"Equipment of Instrumental Accuracy for the Recording and Reproduction of Electrical Signals, Using Cinematographic Film," by H. McGregor Ross. Joint Meeting of Measurements and Radio Sections. Tues., Jan. 4, 5.30 p.m.
"The Economic Selection of Cooling Towers for Generating Stations," by G. F. Kennedy and P. H. Margen; and "The Application of Friction-Heat Transfer Correlations to Cooling-Tower Design," by P. H. Margen. Supply Section. Wed., Jan. 5, 5.30 p.m.
"Problems of Hydro-Electric Design in Mixed Thermal-Hydro-Electric Systems." Thurs., Jan. 6, 5.30 p.m.
BIRMINGHAM
Discussion on "Sandwich Courses," opened by W. H. Taylor. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Jan. 3, 6 p.m.
LEEDS
"The Co-ordination of Insulation of High-Voltage Electrical Installations," by J. S. Cliff. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Jan. 4, 6.30 p.m.
MANCHESTER
"Development and Utilisation of Hydro-Electric Power in Uganda," by J. M. Stock and J. C. Lithgow. North-Western Centre. Engineers' Club, Albert-square, Manchester 1. Tues., Jan. 4, 6.15 p.m.
PORTSMOUTH
"Aluminium-Sheathed Cables," by P. M. Hollingsworth and P. A. Raine. Southern Centre. College of Technology, Portsmouth. Wed., Jan. 5, 6.30 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"The Teaching of Engineering Designers," by Professor E. McEwan. North-East Branch. Northern Architectural Association, 6 Higham-place, Newcastle-upon-Tyne. Mon., Jan. 10, 7.15 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Hydraulic Transmission: The Relative Advantages of Oil and Water." Hydraulics Group. Wed., Jan. 5, 6.45 p.m.
"Impact Torsion Experiments," and "Experiments on the Effects of Rate of Testing on the Criterion of Failure of Certain Mild Steels," by Dr. N. G. Calvert. Applied Mechanics Group. Fri., Jan. 7, 5.30 p.m.
BIRMINGHAM
"Vehicle and Road Illumination," by Dr. J. H. Nelson. Birmingham Automobile Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Tues., Jan. 4, 6.45 p.m.
COVENTRY
"Some Problems in Lubrication and the Substances Called Additives," by A. Towle. Coventry Automobile Centre. Craven Arms Hotel, High-street, Coventry. Tues., Jan. 4, 7.15 p.m.
LEICESTER
Thomas Hawksley Lecture on "Recent Studies of Metallic Friction," by Dr. F. P. Bowden. Annual General Meeting. East Midlands Branch. College of Technology, Leicester. Wed., Jan. 12, 6.30 p.m.
NEWCASTLE-UPON-TYNE
Thomas Hawksley Lecture, by Dr. F. P. Bowden. Annual General Meeting. North-Eastern Branch. Literary and Philosophical Society's Hall, Newcastle-upon-Tyne. Mon., Jan. 10, 6 p.m.

Institution of Production Engineers

CARDIFF
"Standardisation in the Process Industries," by E. W. Greensmith. South Wales and Monmouthshire Section. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Jan. 6, 7 p.m.
NORWICH
"Fuel Efficiency in the Factory," by E. J. Tickner. Norwich Section. Assembly House, Theatre-street, Norwich. Wed., Jan. 5, 7.30 p.m.
NOTTINGHAM
"The Human Aspect in Production Planning and Control," by B. G. L. Jackman. Nottingham Section. Victoria Station Hotel, Nottingham. Wed., Jan. 5, 7 p.m.
WEDNESBURY
"Lock Design and Manufacture," by C. G. Smith. Wolverhampton Section. Anchor Hotel, Wednesbury. Wed., Jan. 5, 7.15 p.m.

Institution of the Rubber Industry

LONDON
"Precision Seals," by J. A. Stephens; and "The Manufacture of Footwear," by Gilbert Crerar. Royal Society of Tropical Medicine and Hygiene, 26 Portland-place, W.1. Tues., Jan. 11, 5.30 p.m.
BIRMINGHAM
"General Rubber Goods," by E. Allcock; and "Latex Thread," by Dr. R. G. James. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Jan. 10, 5 p.m.
SOUTHAMPTON
"Use of Polyisocyanate Resins in the Plastics and Rubber Industries," by Prof. Dr. A. Bayer. Southampton Section. Polygon Hotel, Southampton. Thurs., Jan. 6, 7.30 p.m.

Institution of Structural Engineers

BIRMINGHAM
"Load Factor Methods of Designing Reinforced Concrete," by Dr. F. G. Thomas. Midland Counties Branch. Birmingham and Midland Institute, Paradise-street, Birmingham. Tues., Jan. 4, 6 p.m.
BRISTOL
"Recent Bridge Works in the Bristol District," by H. G. Lakeman. Western Counties Branch. Geology Lecture Theatre, The University, Bristol. Fri., Jan. 7, 6 p.m.
MANCHESTER
"Present Situation on Retaining-Wall Design," by Dr. P. W. Rowe. Lancashire and Cheshire Branch. College of Technology, Manchester. Fri., Jan. 7, 6.30 p.m.

Junior Institution of Engineers

LONDON
Film Evening. Fri., Jan. 7, 7.30 p.m.
BIRMINGHAM
"Power Press Safety," by J. H. Price. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Jan. 5, 7 p.m.

Manchester Association of Engineers

MANCHESTER
"Engineering Practice in the Gas Industry," by T. Andrews. Engineers' Club, Albert-square, Manchester. Fri., Jan. 7, 6.45 p.m.

Reinforced Concrete Association

BIRMINGHAM
"Load Factor Methods of Designing Reinforced Concrete," by Dr. F. G. Thomas. Midland Counties Branch. Birmingham and Midland Institute, Paradise-street, Birmingham. Tues., Jan. 4, 6 p.m.
LIVERPOOL
"Some Applications of Reinforced Concrete in the Gas Industry," by T. Andrews. North-Western Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Wed., Jan. 5, 6.30 p.m.
MANCHESTER
"Some Applications of Reinforced Concrete in the Gas Industry," by T. Andrews. North-Western Branch. College of Technology, Sackville-street, Manchester. Tues., Jan. 4, 6.45 p.m.

Royal Aeronautical Society

LONDON
"Recent Advances in the Knowledge of Transonic Air Flow," by C. H. E. Warren. Section Lecture. Tues., Jan. 4, 7 p.m. Lecture for Young Persons, by P. G. Masefield. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Jan. 6, 3 p.m.

Royal Society of Arts

LONDON
"The Copperbelt of Northern Rhodesia," by R. L. Prain. Commonwealth Section. Thurs., Jan. 6, 5.15 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Discussion on "Open-Hearth Furnaces: Walls, Ends and Ports." Annual General Meeting of the Refractories Group. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield 3. Tues., Jan. 11, 7 p.m.

Society of Instrument Technology

GLASGOW
Discussion on "The Installation of Temperature-Measuring Instruments. Annual General Meeting. Scottish Section. Natural Philosophy Department, Royal Technical College, Glasgow. Fri., Jan. 14, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Bronze and Brass Founders, 69 Harborne-road, Edgbaston, Birmingham 15. (Edgbaston 4141.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Refrigeration, Dalmeny House, Monument-street, London, E.C.3. (MINcing Lane 6851.)
Institute of Welding, 2 Buckingham Palace-gardens, London, W.1. SLOane 9851.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 20 Booth-street, Manchester 2. (Central 2796.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield 7. (Sheffield 53674.)
Society of Instrument Technology, 184 Sherwood Park-road, Mitcham, Surrey.

Labour Notes

LONDON AIRPORT DISPUTE

An early settlement was reached in a dispute which arose at London Airport on December 17. On that date, British European Airways summarily dismissed 315 members of their engineering staff at the airport for what they regarded as a flagrant defiance of a management ruling.

The direct cause of their action was the attendance of these men at a mass meeting on the morning of the same day, in spite of instructions that they should not leave their work. At that unauthorised meeting, support was given for a ban on overtime and for the institution of slow-working tactics, conduct which the airport management regarded as being " calculated to paralyse " the activities of the Corporation and " to sabotage " the loyal endeavours of the men's workmates.

It may be noted that the men dismissed were all members of the engineering, maintenance, and repair staffs in the employ of the Corporation at their main engineering base and that they were not engaged on the minor inspection of aircraft between flights.

An immediate meeting was arranged between Mr. Peter Masefield, chief executive of the Corporation, and Mr. J. Matthews, the trade union secretary of the National Joint Council for Civil Air Transport at the airport, following which it was announced by the Corporation that any of the dismissed men who presented themselves for work on the following Monday morning would be interviewed individually, with a view to their re-engagement.

UNION ACTIVITIES DURING PAID EMPLOYMENT

The men were advised by a union official to take advantage of the Corporation's offer and no fewer than 137 applicants for re-employment were interviewed on December 20 alone. Most of the rest were interviewed on the day after.

It was a condition of their resuming work that each man should give an undertaking to abide by the procedures laid down under the constitution of the National Joint Council and that he should agree to comply fully with the regulations of British European Airways.

According to a statement issued by the Corporation, Mr. Matthews had emphasised, at his meeting with Mr. Masefield, that the men who were dismissed had been " completely misled " by shop stewards. They had not, he said, been given a proper opportunity to understand the instructions of their national trade union secretary, Mr. E. Roberts, who, in a letter on December 10, had urged the men to observe the recognised negotiating machinery and to withdraw suggestions for a ban on overtime which had been made previously.

Those proposals had been put forward in connection with a dispute with the Corporation regarding the amount of time which a particular shop steward should be allowed for union activities during paid employment. According to the Corporation's statement, he had been granted 11¼-hours' paid time each week for his normal trade-union work, with the proviso that, when exceptional circumstances arose, more time might be allowed by arrangement with the management. This concession had not met fully the views of the man concerned and he had desired to have even more time.

It was emphasised by the Corporation that men who were re-engaged would not be regarded as having broken the continuity of their periods of service and that their pension rights would be preserved. There would be no recriminations or penalties against those operatives who returned to work after having agreed to the pledges in the new contracts.

NATIONAL UNION OF RAILWAYMEN URGED TO NEGOTIATE AGAIN

The further reply promised by Mr. J. A. Boyd-Carpenter, the Minister of Transport and Civil Aviation, on the problem of railway wage claims was sent to the National Union of Railwaymen on December 20.

In his letter, Mr. Boyd-Carpenter largely reiterated the advice he gave to a deputation from the union on December 13. He suggested, in effect, that the Government could not consider the financial difficulties of the British Transport Commission, in relation to the wages paid to their employees, at any rate until the union had taken its claim through all the stages of the railway-industry's negotiating machinery.

When the deputation saw the Minister on December 13, they told him that the Commission was not able to offer further increases in the wage rates of their workpeople owing to their financial position, and that, in those circumstances, the union felt that it must ask for the assistance of the Government.

The union's leaders also referred to the £124 million which accrued to the Government as a result of the war-time operation of the railways and proposed that some of that money might be used to strengthen the Commission's finances.

In his reply on that occasion, the Minister said that he could not contemplate anything in the nature of a subsidy to the Commission as a means of assisting them to meet higher wage claims, and he advised the union to resume its negotiations with the Commission.

DECISION TO STRIKE

In his letter to the union, Mr. Boyd-Carpenter said that he had discussed the points raised by the union's leaders with the British Transport Commission and that they had drawn his attention to the recent award of the Railway Staff National Tribunal on increased rates of pay for footplate men. This award, the Commission felt, might be considered by the National Union of Railwaymen to have created anomalies in connection with the wage rates for some other sections of railway employees.

The Commission had informed Mr. Boyd-Carpenter that they were prepared to discuss at once any claim founded on such a contention, but the demand recently put forward by the union had been found to go much further than that. In view of this, the Commission took the view that the demand should be referred to the Tribunal, in order that the conclusions on which that body based its award of increased rates for the footplate staffs might be available for consideration in respect of the claim of the other grades whose case had been presented by the union. Only in this way, the Commission had felt, would it be possible to obtain an adequate settlement for all grades.

Another point referred to by the Commission, Mr. Boyd-Carpenter told the union, was that they intended to consult him regarding the effect on their statutory obligations if the Tribunal suggested that they should concede all, or the greater part, of what the union was endeavouring to obtain.

The Minister's views were considered at a meeting of the executive committee of the union on December 21, at which it was decided to call out on strike, as from midnight on Sunday, January 9, all members of the union employed by British Railways.

The committee adhered to its opinion that all the industry's negotiating machinery had been exhausted and that the increases for which it was pressing were in continuance of the claim for a 15 per cent. advance in wages presented in October, 1953.

OTHER RAILWAY WAGE CLAIMS

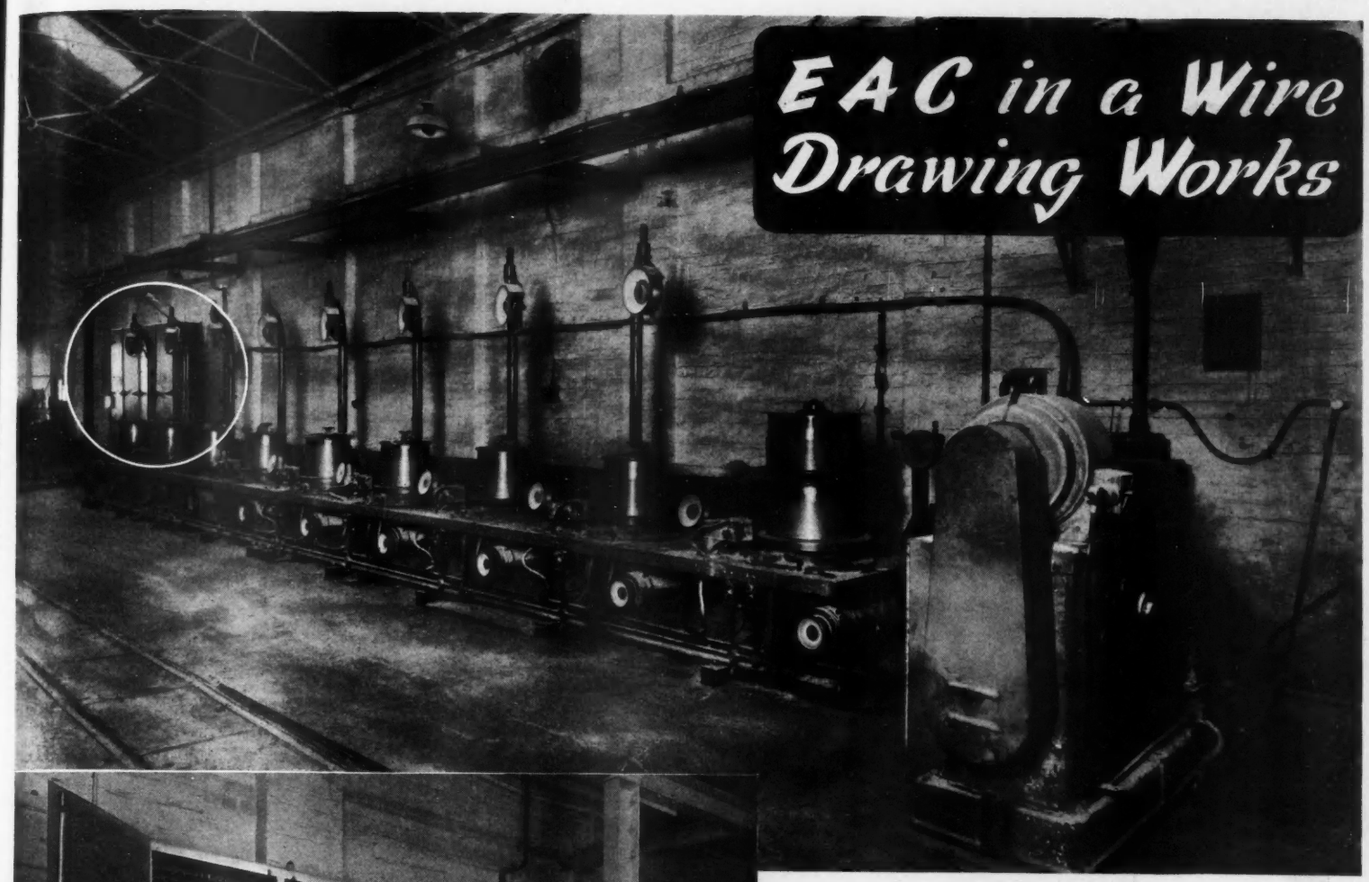
Definite steps were taken on December 20 in connection with wage claims on behalf of two other sections of the railway industry. One of the claims concerned was a demand for higher rates of pay for operating and locomotive staffs employed on the underground system of the London Transport Executive. This demand was submitted to the London Transport Wages Board for arbitration and it is estimated that the wages of about 12,000 men will be affected by the Board's decision.

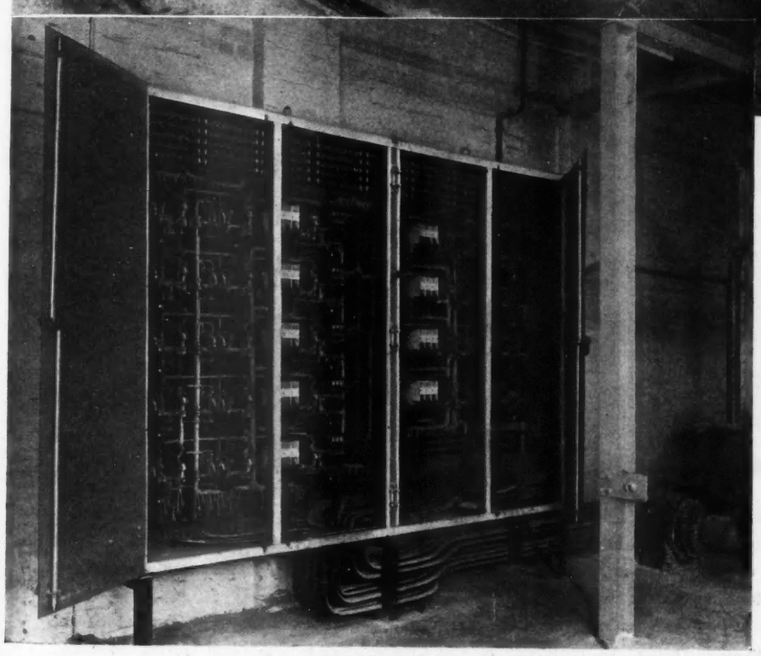
The other claim involved engineering and other employees in the railway workshops, on whose behalf the trade-union side of the Railway Shopmen's National Council decided, at a meeting in London, to make an immediate application for higher wages to the British Transport Commission. The unions' proposals were for an increase of 15*s.* a week for skilled men, 12*s.* 6*d.* a week for semi-skilled operatives, and 10*s.* a week for labourers.

Rather more than 120,000 men employed in various capacities in the workshops of British Railways are involved in this claim, the main points of which are in line with the demands placed before the Engineering and Allied Employers' National Federation by the engineering unions on December 14.

END OF THE 178TH VOLUME

E.A.C. in a Wire Drawing Works





(above) 9-motor wire drawing machine with foot-operated switches and (in circle) E.A.C. 9-motor automatic control panel, a close-up view of which is pictured on the left.

THE illustrations show a typical example of multi-motor starting equipment in which E.A.C. gear is controlling and protecting wire drawing machinery supplied by Barron & Crowther Ltd., to the Coatbridge Works, of The Speedwell Wire Co. Ltd. The installation comprises a 9-motor contactor panel fitted to a 9-block machine. Each block is individually driven by a 30 HP slipring motor controlled by Start/Stop push buttons and inching pedals.

Apart from its normal duty the gear must be capable of 'inching' during the threading stage, and must withstand extra severe conditions as when dealing with a particularly bad batch of wire.

E.A.C. are always pleased to advise on any motor control gear problem.

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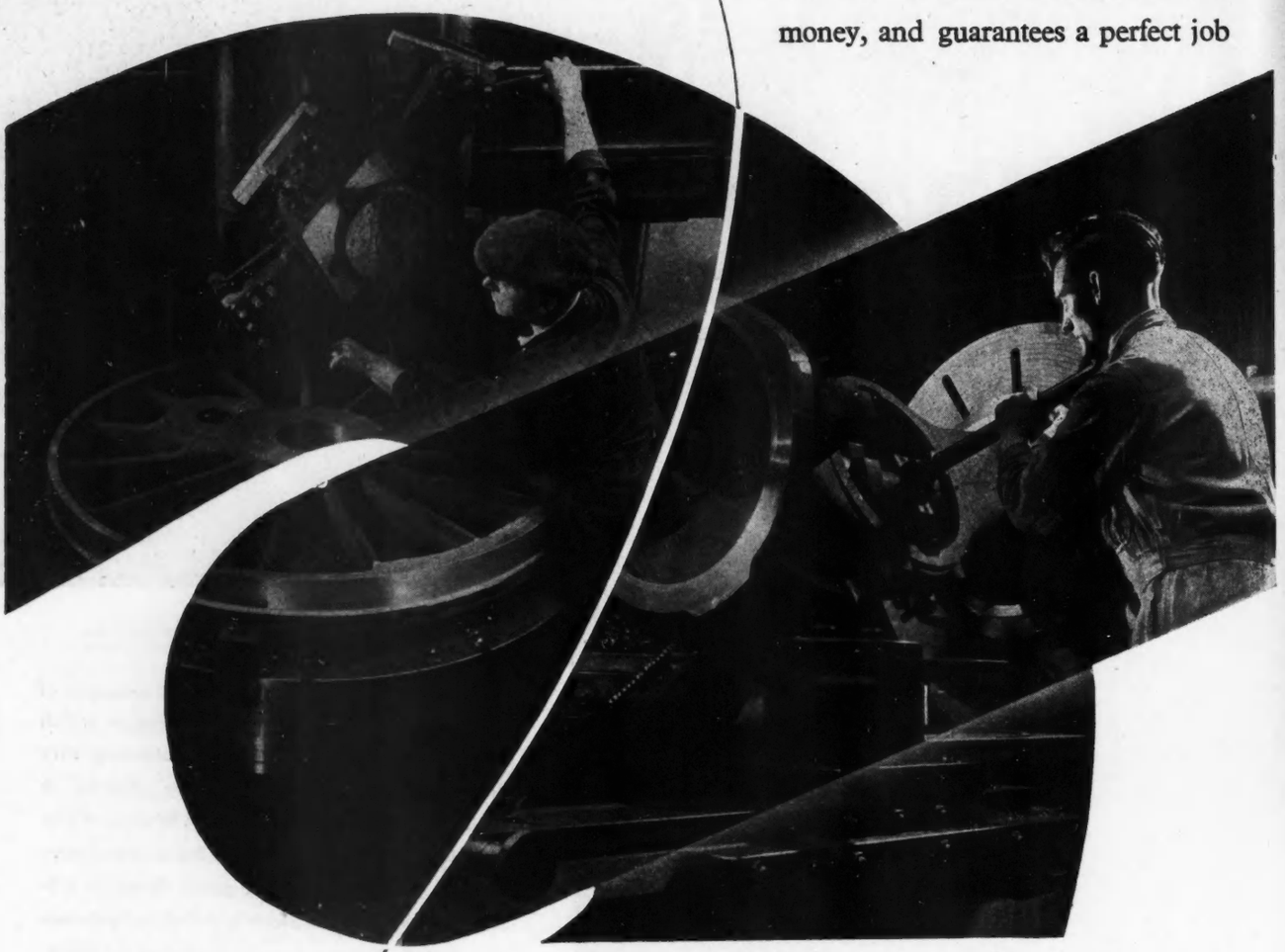

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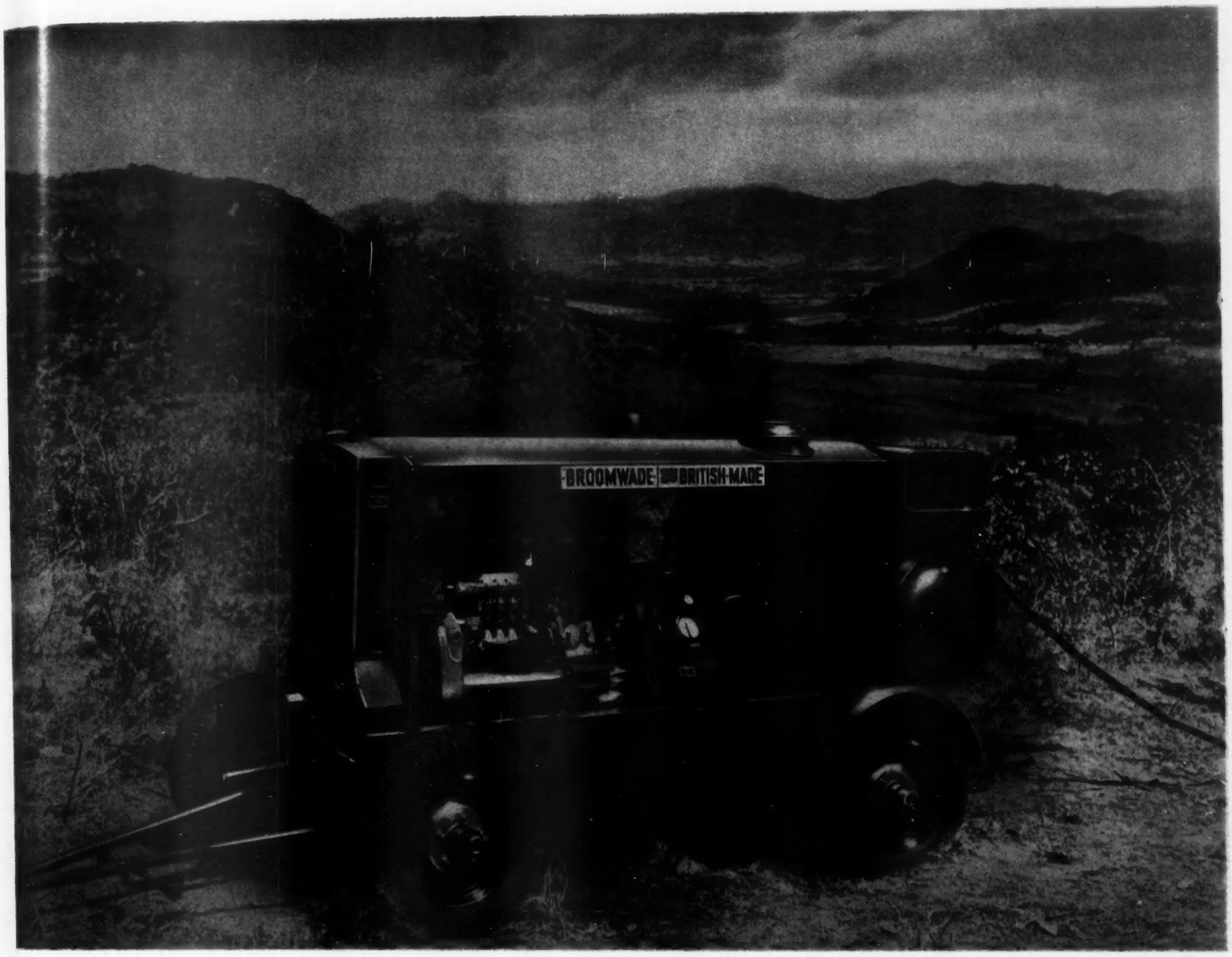

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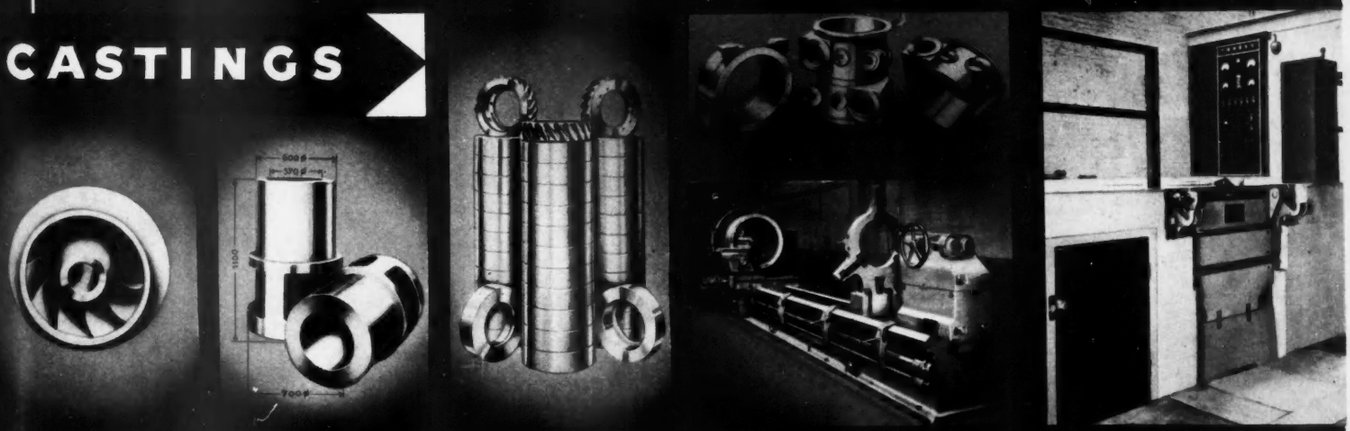

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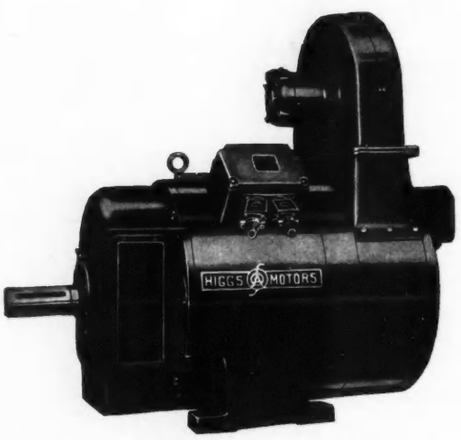

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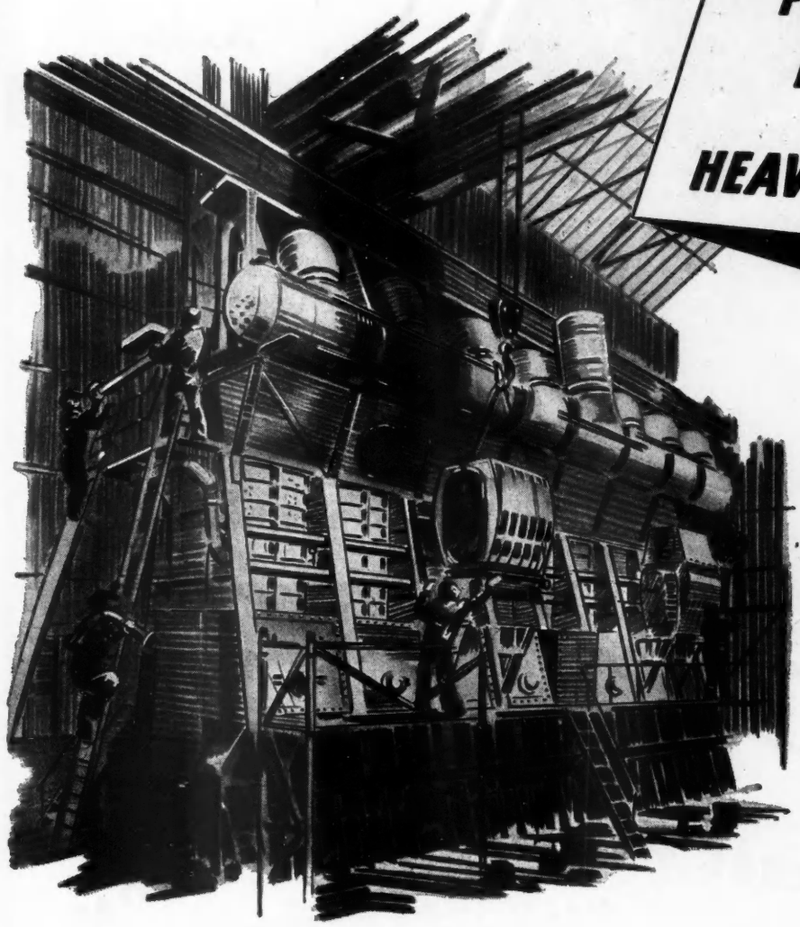

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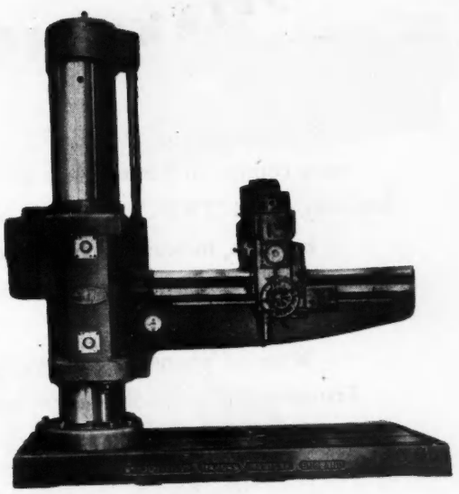

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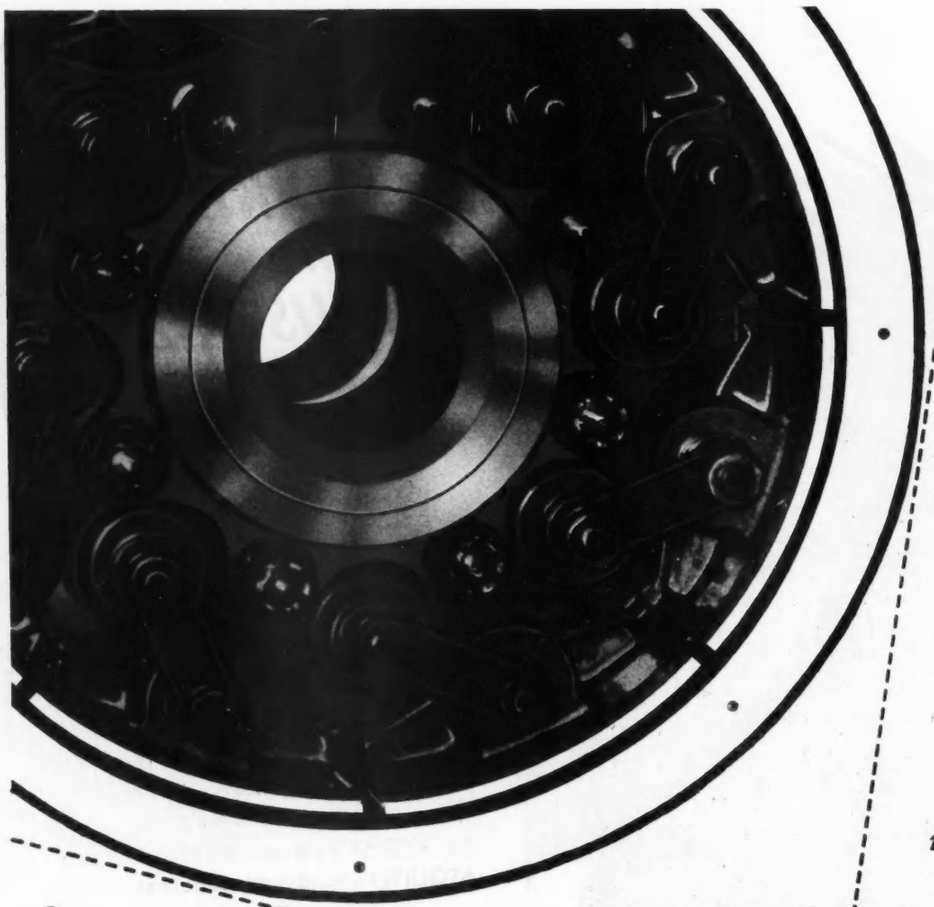

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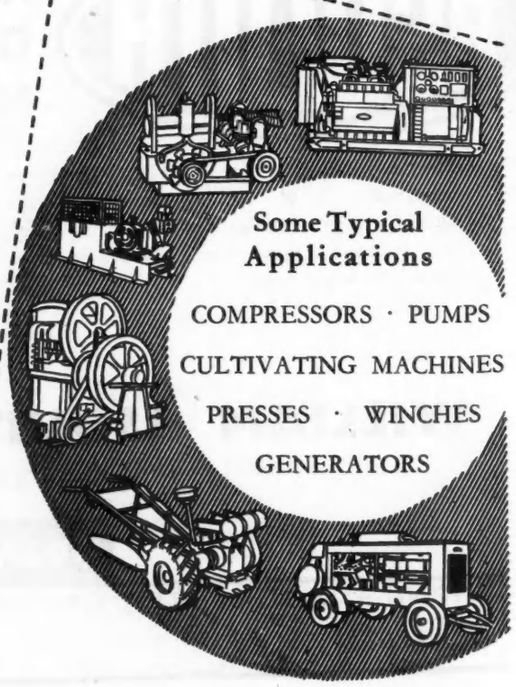

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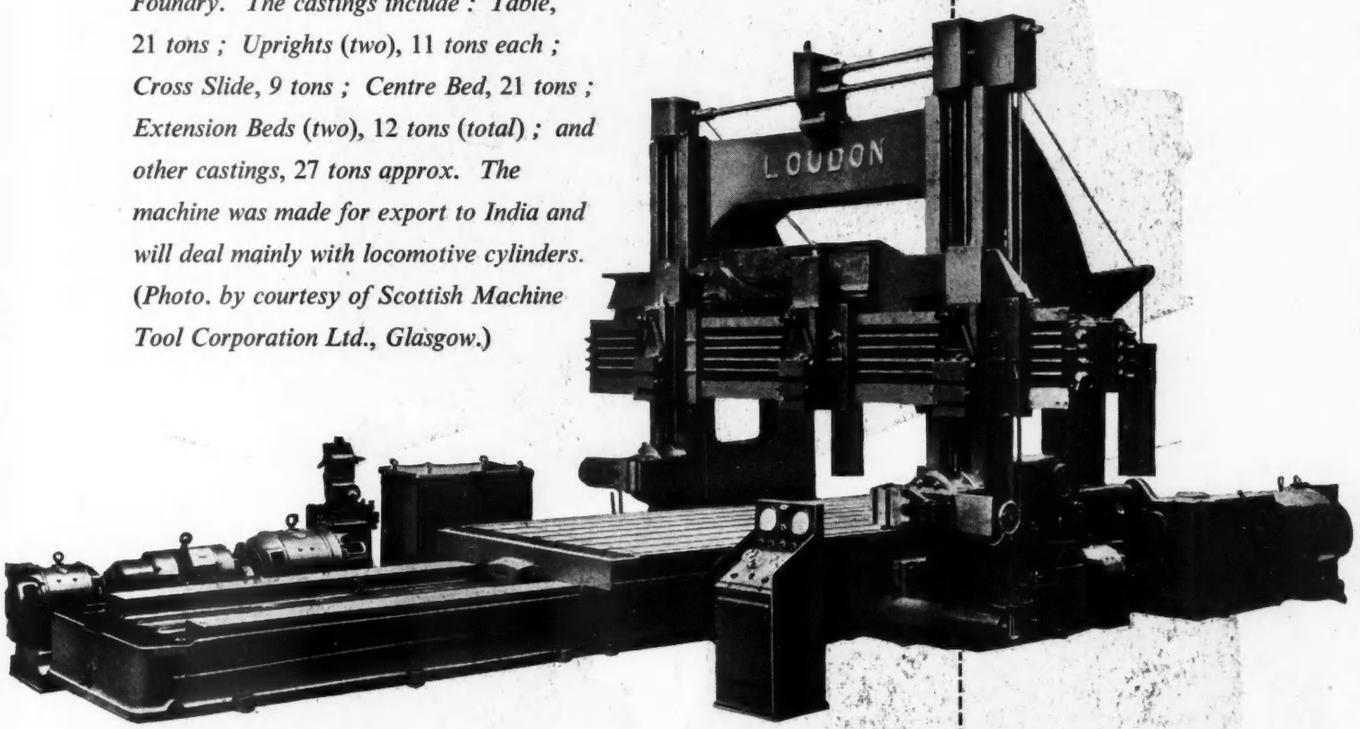
Castings by Carron...

This large Planing Machine contains approximately 112 *tons of iron castings, all of which were made in Carron's Heavy Foundry. The castings include : Table,* 21 *tons ; Uprights* (*two*), 11 *tons each ; Cross Slide, 9 tons ; Centre Bed,* 21 *tons ; Extension Beds* (*two*), 12 *tons* (*total*) *; and other castings,* 27 *tons approx. The machine was made for export to India and will deal mainly with locomotive cylinders.* (*Photo. by courtesy of Scottish Machine Tool Corporation Ltd., Glasgow.*)



Carron's Heavy Foundry produces high-class castings up to 40 tons in weight for leading manufacturers of machine tools, laundry and sugar machinery, and chemical and general engineering plant. Castings are made in either drysand, greensand or loam ; loam work is a speciality. If you have heavy casting problems bring them to Carron.

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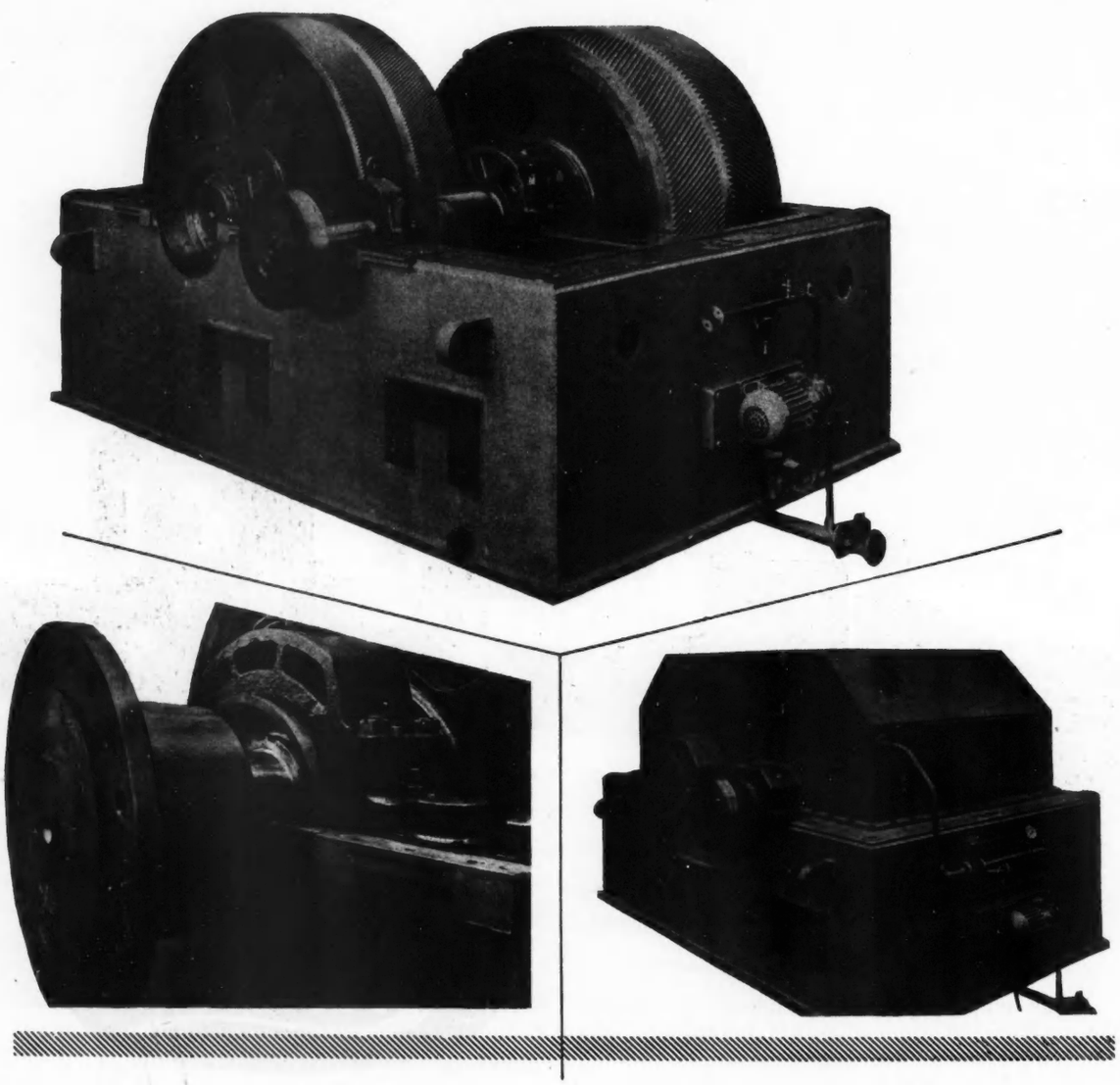
D.25

This large double-reduction gearbox runs on SKF SPHERICAL ROLLER BEARINGS



The 800 h.p. co-axial gearbox illustrated here is one of a number of 750/21 r.p.m. double reduction gearboxes made by David Brown & Sons (Huddersfield) Ltd. for driving cement mills. SKF bearings were chosen to carry the extremely heavy loads and are fitted in all positions.

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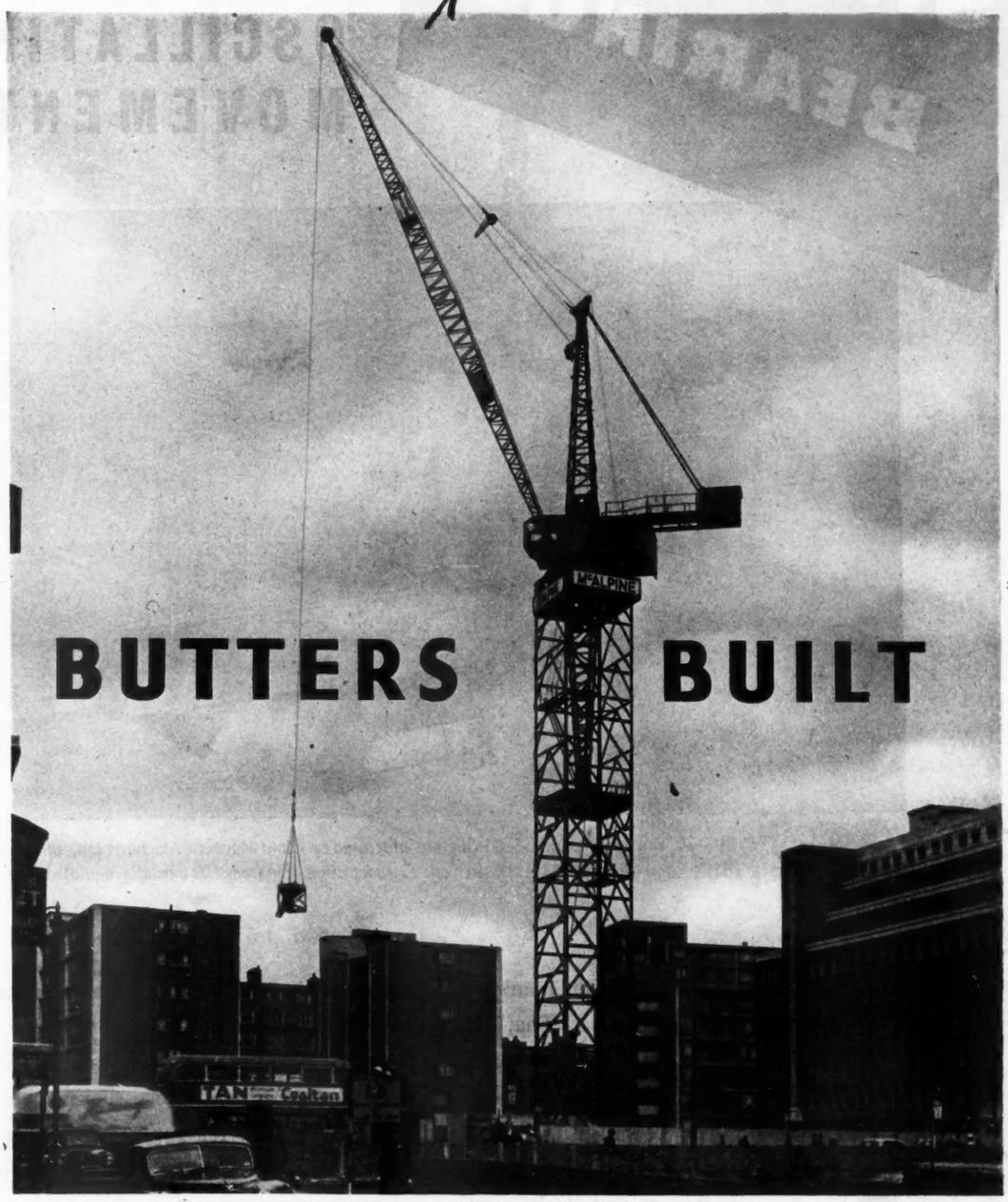

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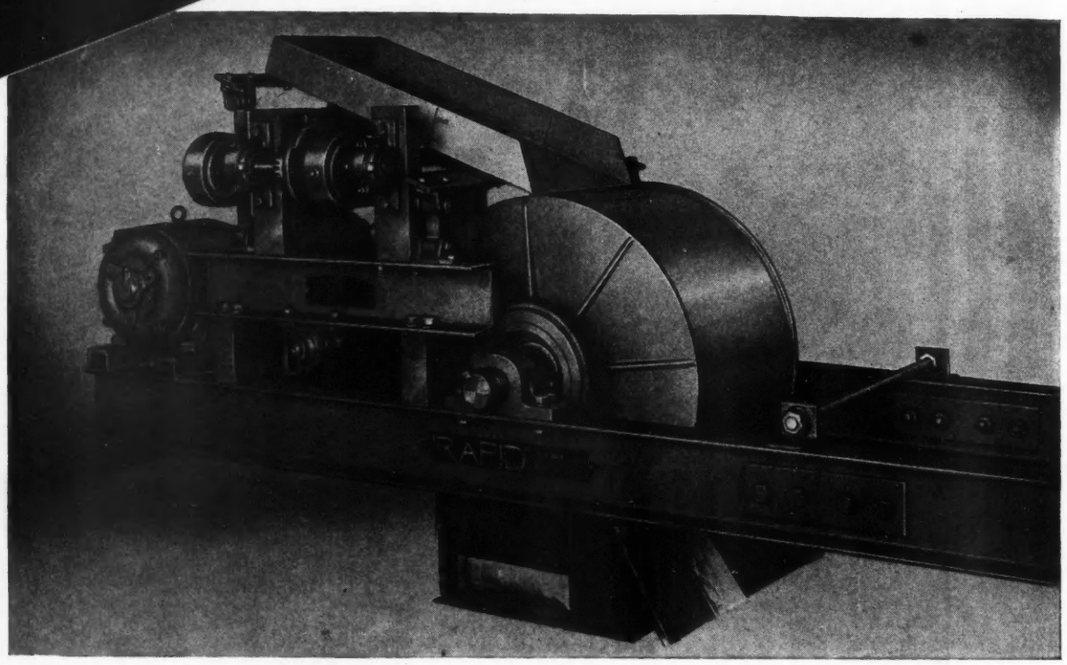
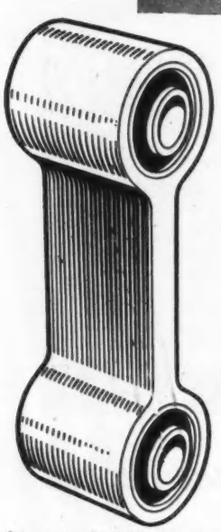


This type of Magnetic Drum Separator manufactured by Rapid Magnetic Machines Ltd., of Birmingham, runs continuously for 6 months at a stretch and extracts tramp iron from 170 tons of granulated sugar in 24 hours.



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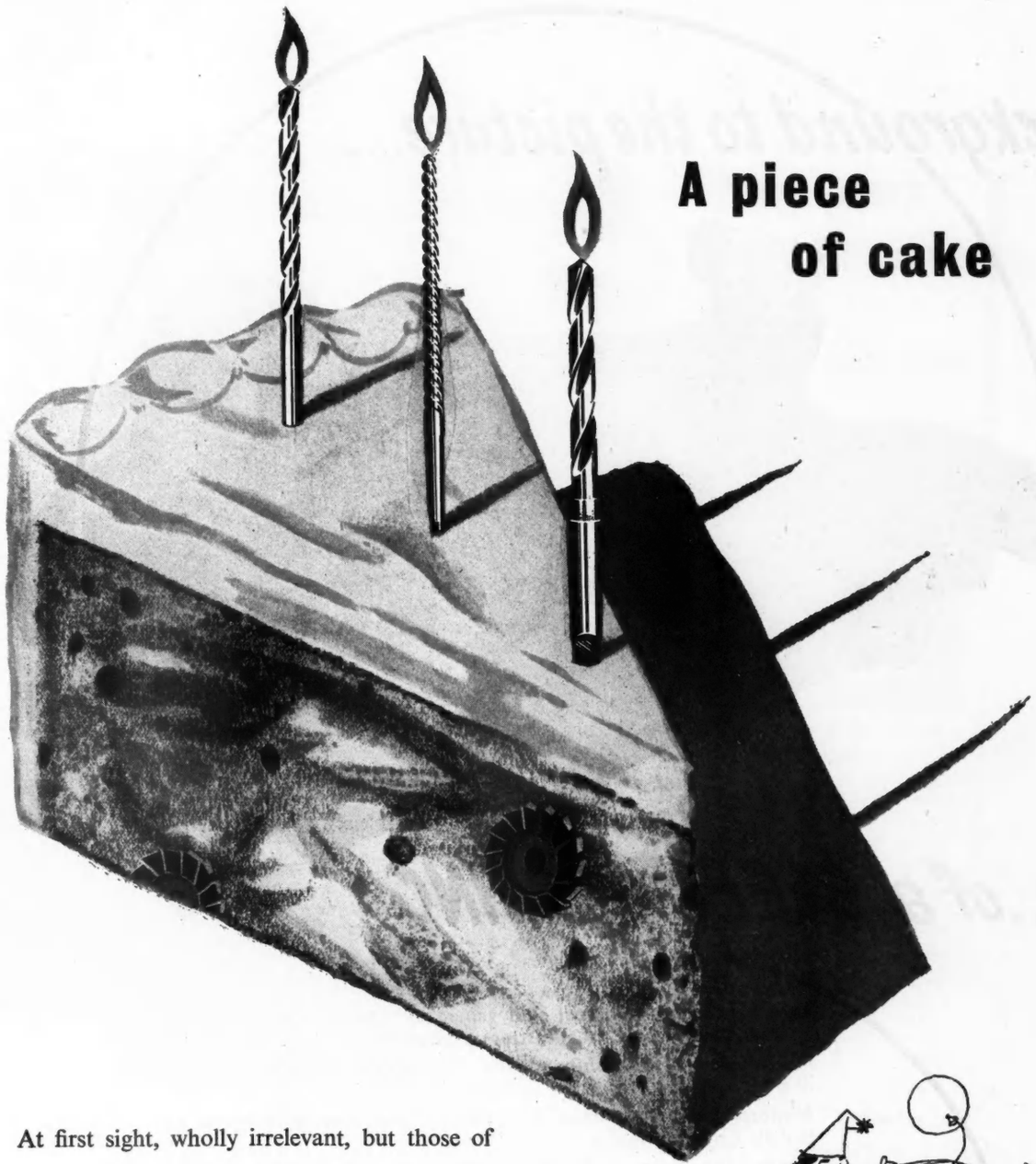

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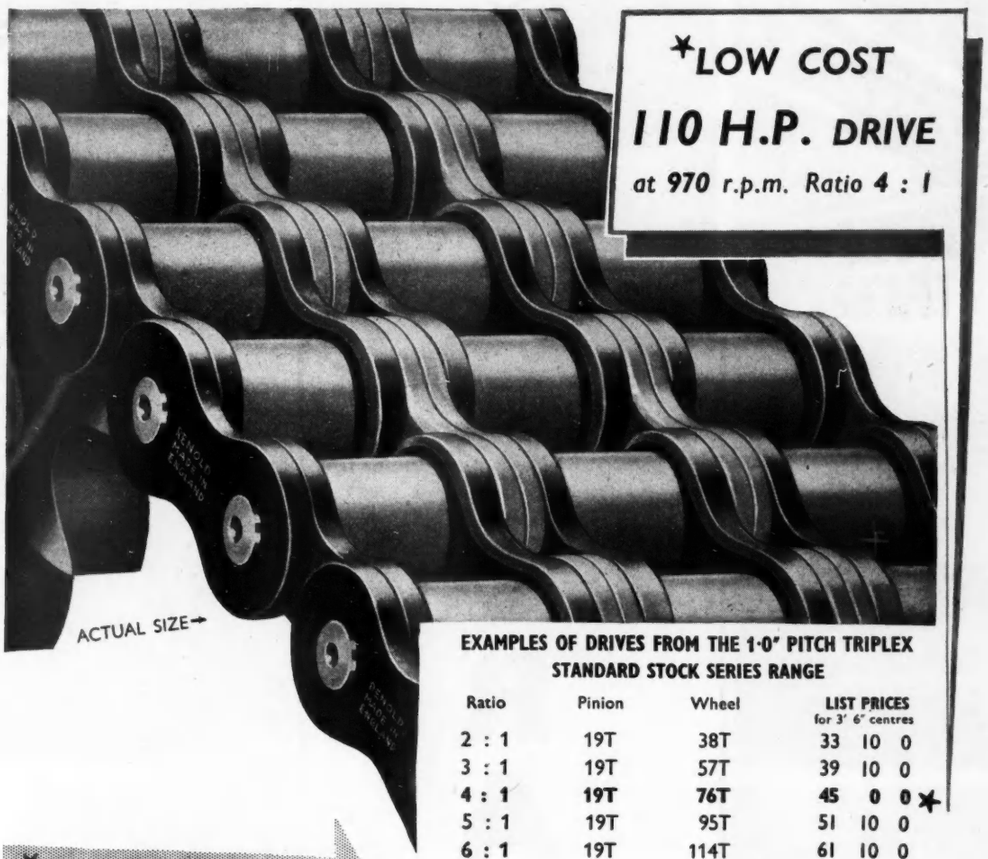

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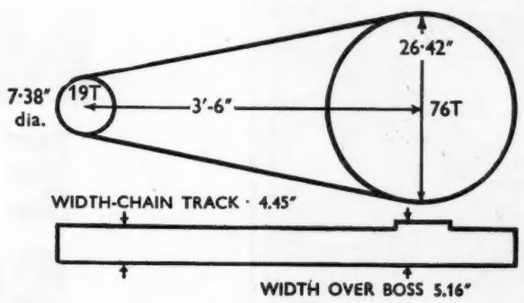

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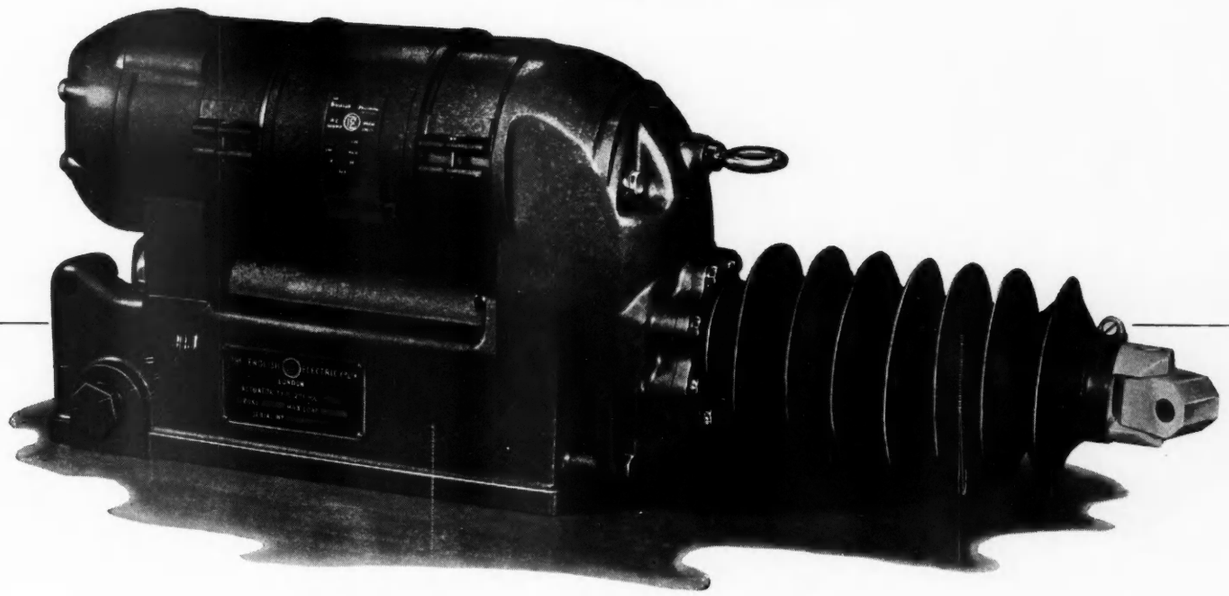

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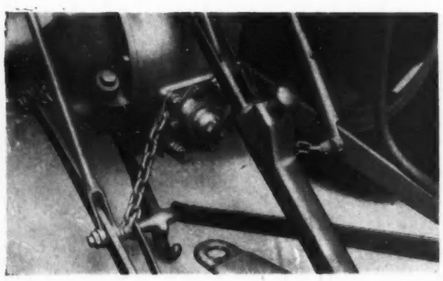
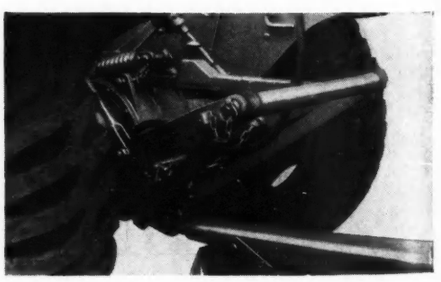


Trailer is automatically hitched — simply drive tractor hook under trailer towing eye.

Lift fingertip control lever to raise hook and engage eye.

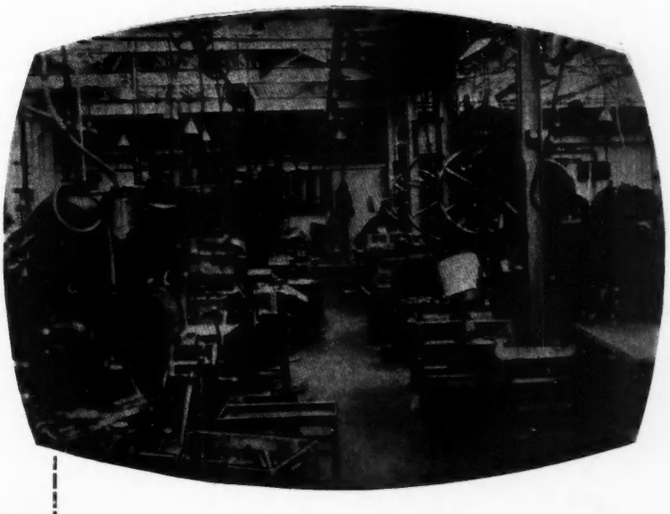


Trailer in transport position ready to drive away. Unhitching is just as simple.

Ferguson in Industry

Ferguson tractors, sold by Massey-Harris-Ferguson (Sales) Ltd., are manufactured by The Standard Motor Co., Ltd., Coventry

Wise finance changes the picture



ICFC capital made possible the complete rebuilding of the premises of this foundry and engineering business. The old machine shop (top) contrasted with the assembly line and part of the machine shop in the new works.

ICFC capital has changed the picture for many industrial organisations by financing new buildings, new plant and schemes of general expansion. The Corporation provides finance in the form of long-term loans on fixed terms or share capital, to industrial and commercial enterprises in Great Britain. Amounts range normally between £5,000 and £200,000. Formed in 1945 by the English and Scottish banks, ICFC has already aided the expansion of British industry by loans totalling over £38,000,000.

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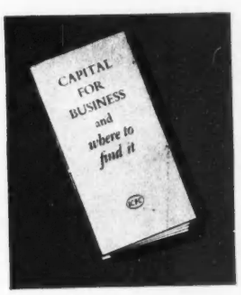

P.3

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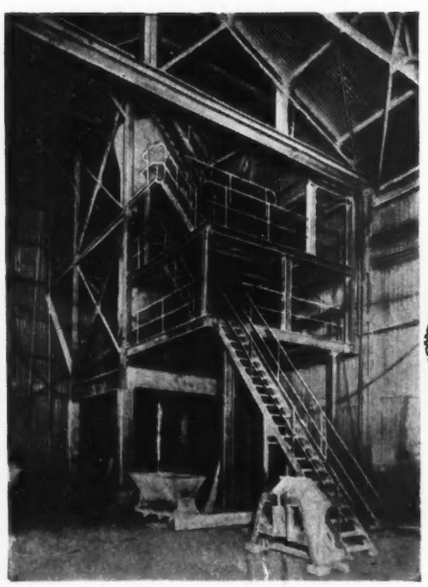

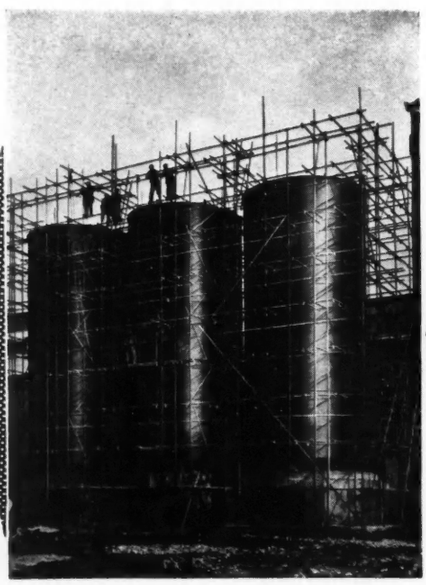

1 Ground floor interior view showing progress in construction of a vertical Kiln together with supporting steelwork, platforms and stairs.

2 Three circular riveted Silos approaching complete erection

The above illustrations show plant and equipment recently installed by us at the South Ferriby, Lincolnshire works of Messrs. Eastwoods Cement Limited.
These illustrations of site work by Rileys are published by courtesy of Messrs. Eastwoods Cement Ltd., 158/160, City Road, London, E.C.1. These examples are typical of contracts for new installations, and in other cases Factory extensions which are undertaken by the Riley Organisation.

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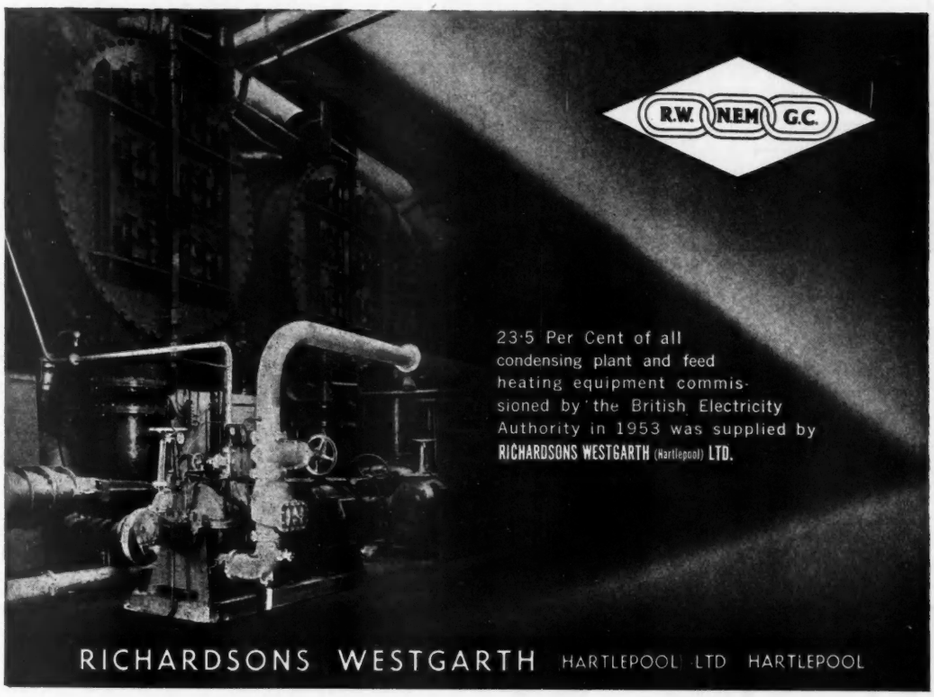
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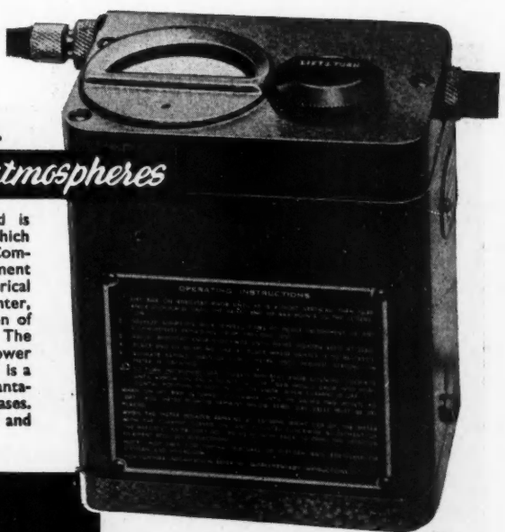

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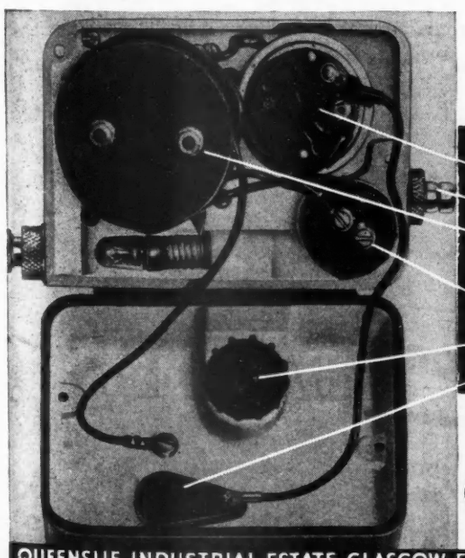
A sample of the atmosphere to be tested is drawn over a heated catalytic filament which forms part of a balanced electrical circuit. Combustibles in the sample are burned on the filament and the resultant unbalance of the electrical circuit causes a deflection of the meter pointer, thus indicating on the scale the concentration of combustible gases or vapours in the sample. The scale is graduated in percentage of the lower explosive limit. The M.S.A. "Explosimeter" is a complete unit in itself, which registers instantaneously concentrations of hydro-carbon gases. Compact, sturdy and light, it is simple to use and efficient in operation.



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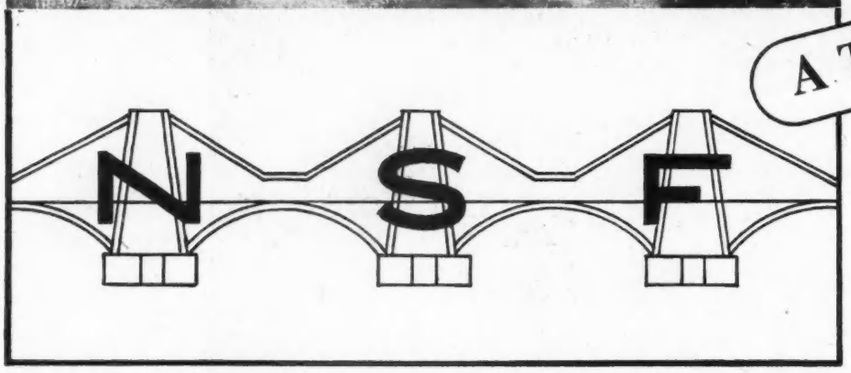

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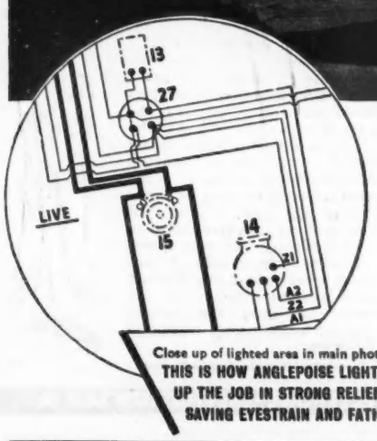

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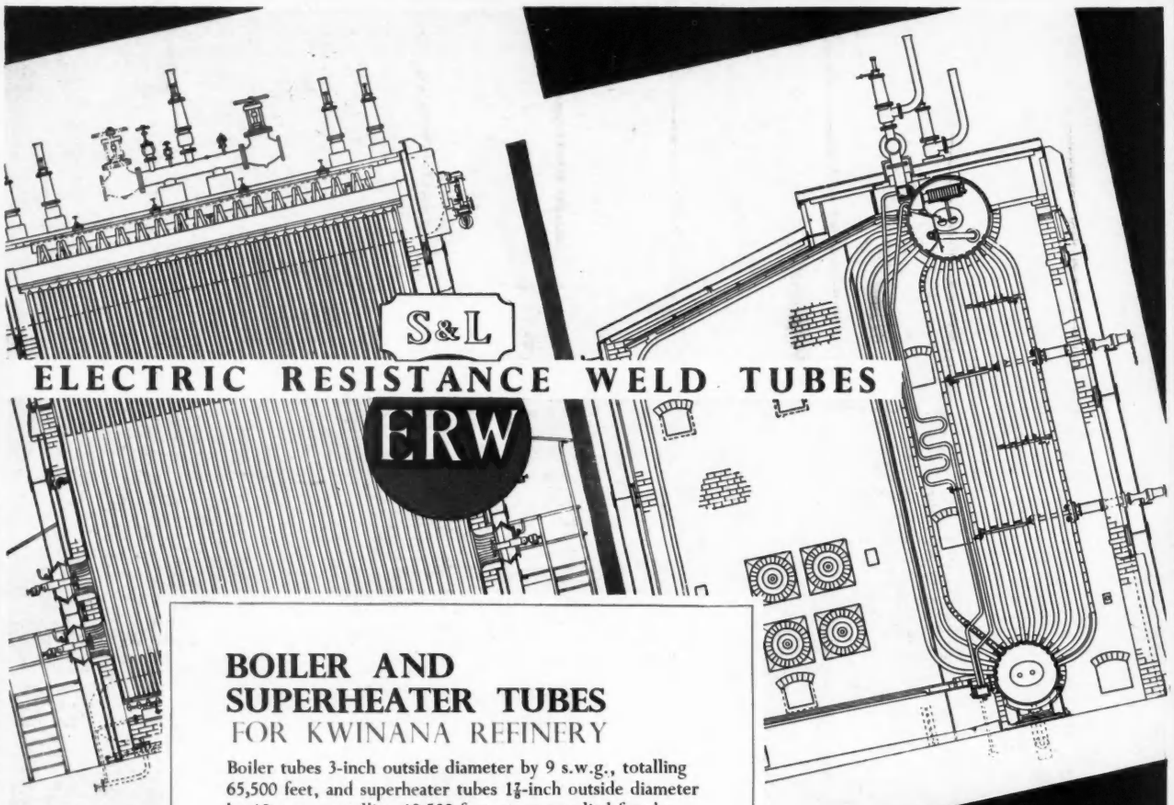

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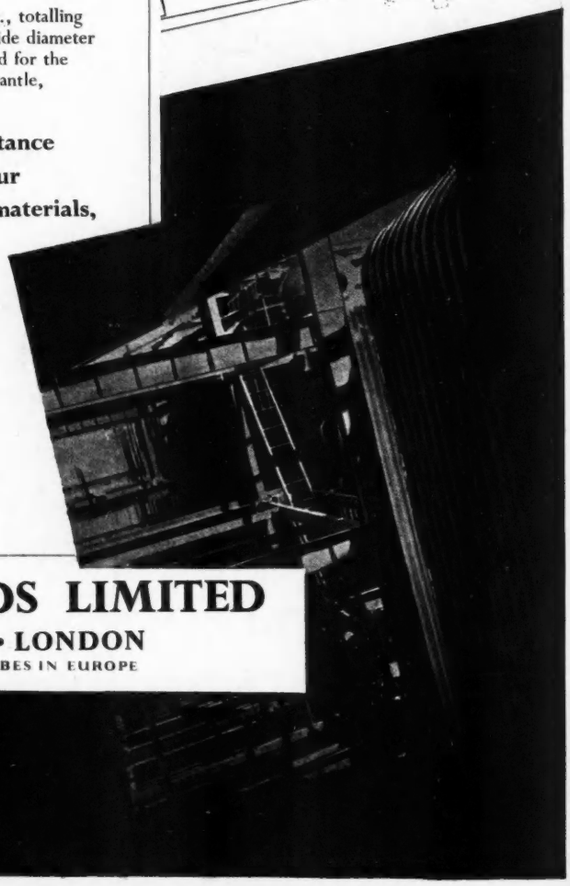

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